Cross Jurisdictional Barriers to Effective Wastewater Reuse: Management of Wastewater Disposal, Water Quality Impacts, and Reform Opportunities for Australia

by

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Abstract

Reduced wastewater disposal through reuse can provide improved environmental, economic and social outcomes. Under the Australian Constitution, states and territories have the power to make laws over water and therefore there is considerable variation in the approaches taken by various Australian jurisdictions to urban wastewater management, urban water industry governance, and the management of discharge environments including recreational water. This thesis considers whether urban water governance, environmental regulation and recreational water quality management impact decisions to either reuse urban wastewater or dispose of it to the environment, and identifies opportunities for reform.

Chapter 2 reviews Australian urban wastewater management and environmental regulation and barriers to wastewater reuse. Australian water quality standards are contained in non-binding national guidelines which are applied by states in policies and licences granted under pollution control legislation. A range of barriers to wastewater recycling have been identified including an inability to account for the external impacts of water management.

Chapter 3 follows with a case study of the decision process for a wastewater reuse scheme in Beaconsfield, Tasmania. Circumstances leading to recent reform of urban water management and historically poor environmental performance are described. These demonstrate how investment decisions are biased by urban wastewater governance, economic policies for pricing and profits, application of principles of competition in absence of competition, and the level of past investment.

Chapter 4 considers how environmental management and other factors may impact assessment of costs and benefits of reuse. This is done by comparing the Chapter 3 case study (Beaconsfield) to wastewater reuse planning by Hunter Water (NSW) revealing that the feasibility of wastewater reuse technologies changes with the conditions in which the feasibility of reuse is framed; in Tasmania, different outcomes were observed under the same non-binding environmental guidelines and influences including 1) the comparative level of formality or transparency in the assessment processes, 2) the different drivers for wastewater reuse (environmental protection or water scarcity), and 3) the ability for environmental regulations to account for external impacts of wastewater disposal; providing new knowledge to this research area.

In order to test an assumption within reuse feasibility assessments that effective Australian environmental regulations negate the economic impacts of discharge as a benefit from wastewater reuse, Chapter 5 examines Australian recreational water quality management, drawing on examples from the USA and more progressive Australian jurisdictions. This represents the first study of the legal efficacy of Australian recreational water management, also providing new knowledge. The chapter concludes that despite national guidelines, there remains high inter-jurisdictional variation in

recreational water quality management. Recommendations for reform include: 1) management actions based on single high samples, 2) consistent communication, 3) consistent microbiological limits, 4) consistent levels of acceptable health risk for primary and secondary recreational activities, and 5) model policy mechanisms to facilitate these.

Two further case studies support the findings of Chapter 4. Firstly, Chapter 6 considers wastewater discharges by Melbourne Water Corporation at Gunnamatta beach in Victoria, Australia, identifying that even though the discharge was apparently compliant with legislation and policy, there was environmental degradation, a divergence from the national approach for recreational water quality management to a less accurate methodology, and a water authority that stated or implied that their discharge represented no risk to human health; all of which has the potential to affect bathers' abilities to make informed and safe recreational choices. Secondly, in Chapter 7, management of Combined Sewage Overflows (CSO) in Tasmania and the USA are compared demonstrating that the application of non-binding national and state water quality guidelines has facilitated a parlous level of infrastructure investment. A case study of proposed US laws, which would require public notice when untreated effluent is disposed from CSOs, is put forward as a model for reform.

Weaknesses in recreational water quality management and variation in the extent to which environmental regulations and monitoring programs account for impacts of wastewater disposal contradict the key assumption used when comparing economic costs and benefits of wastewater disposal and wastewater reuse. The assumption is that Australian environmental regulation is effective and therefore compliance reflects socially optimal conditions. Inadequate recreational water management is therefore a new barrier to wastewater reuse which acts alongside the barriers to wastewater reuse identified earlier in the thesis. Proposed reforms include; 1) the ability of decision makers to account for the external impacts of wastewater disposal, 2) improved communication of the externalities of disposal which impact community willingness to pay for recycled water, and 3) mechanisms for more consistent application of non-binding environmental guidelines. Addressing these will assist the incorporation of the true costs of wastewater disposal into decisions to either reuse or dispose of wastewater.

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"The mountains are calling and I must go"   - John Muir

List of abbreviations

ABC - Australian Broadcasting Corporation

ACT - Australian Capital Territory

ANZECC - Australian and New Zealand Environment and Conservation Council

ANZECC 2000 - Australian and New Zealand guidelines for fresh and marine water quality, Vol. 1

AMT - Accepted Modern Technology

ARMCANZ - Agriculture and Resource Management Council of Australia and New Zealand

cce - Calibrator cell equivalent

cfu - Colony forming unit

Clean Water Act - Federal Water Pollution Control Act "Clean Water Act" (1972)

CMA - Catchment Management Authority

COAG - Council of Australian Governments

CSO - Combined Sewer Overflow

DPR - Direct Potable Reuse

DHHS - Department of Health and Human Services, Tasmanian Government

DP&EMP - Development Proposal and Environment Management Plan

DPIPWE - Department of Primary Industries Parks Water and Environment, Tasmanian Government

E. Coli - *Escherichia coli*

EHO - Environmental Health Officer (Local Government)

EMPC Act - Environmental Management and Pollution Control Act 1994 (Tas)

EPA - Environment Protection Authority/ Environment Protection Agency[1]

EP Act - Environment Protection Act

EPHC - Environment Protection Heritage Council

[1] Some jurisdictions use the term “Environmental” or “Agency”.

EPN - Environment Protection Notice

GM - Geometric Mean

IPR - Indirect Potable Reuse

NGO - Non Governmental Organisation

Master Plan - Hunter River Catchment Effluent Management Master Plan (HRCEMMP)

LGAT - Local Government Association of Tasmania

LTCP - Long Term Control Plans

IGAE - The Intergovernmental Agreement on the Environment (1992)

IPART - Independent Pricing and Regulatory Tribunal (NSW)

kl - Kilolitre (1000 litres)

L - litre

mg - Miligram

ml - Milliliter

NEPC - National Environment Protection Council

NEPM - National Environment Protection Measure

NHMRC - National Health and Medical Research Council

NHMRC 2008 guidelines - National Health and Medical Research Council Guidelines for Managing Risks in Recreational Waters 2008

NWC - National Water Commission

NWI - National Water Initiative

NWQMS - National Water Quality Management Strategy

NSW - New South Wales

NPI - National Pollutant Inventory

OH&S - Occupational Health and Saftey

PEV - Protected Environmental Value

POEO - Protection of the Environment Operations Act (NSW)

QMRA - Quantitative Microbial Risk Assessment

QPCR - Quantitative Polymerase Chain Reaction

SA - South Australia

SCCWRP - Southern California Coastal Water Research Project

SEPP - State Environment Protection Policy

SKM - Sinclair Knight Merz

SPWQM - State Policy on Water Quality Management (Tasmania)

STV - Statistical Threshold Value

TEER - Tamar Estuary and Esks Rivers Program

USA, US - United States of America

US EPA - United States Environment Protection Agency

Victorian EP Act - Environment Protection Act 1970 (Vic)

WA - Western Australia

WHO - World Health Organisation

WQOs - Water Quality Objectives

WQIP - Water Quality Improvement Plan

PART 1 – INTRODUCTION AND POLICY FRAMEWORK

2 Introduction, background, methods

2.1 Introduction

This thesis focuses on two seemingly disparate themes; environmental regulations which manage waters where wastewater is disposed, and the assessment of the feasibility of urban wastewater reuse. In particular it investigates Australian legislation, policy and management of recreational water quality, providing case studies from Australia and the US, with a goal of identifying specific aspects of environmental regulation of receiving waters impacted by wastewater which act as barriers to wastewater recycling. It concludes that in many jurisdictions recreational water quality management is not optimal and may impact assumptions used when assessing the feasibility of wastewater reuse.

Wastewater treatment plants (WWTPs), collect and treat urban wastewater, removing faecal solids and the associated pathogens (bacteria, viruses and protozoa), improving water quality. Wastewater which is not recycled is disposed to surface waters. In the case studies in this thesis urban wastewater is collected at urban WWTPs, treated and then either reused or disposed to the ocean or other waters. Wastewater reuse is the alternative to environmental disposal, and therefore recreational water quality was selected for study as an integral aspect of the lifecycle of wastewater, which to the author's knowledge, has not yet been considered within the study of barriers to wastewater reuse. Although the primary focus of this thesis is to examine environmental regulation and its interaction with decisions to reuse wastewater, the thesis also considers interconnected themes such as economics, governance structures for urban water management, known barriers to wastewater reuse, and marine and health sciences.

All of the case studies in this thesis consider water quality management and microbiological water quality in areas where wastewater is disposed and wastewater reuse has been investigated. In addition to a review of communication of microbiological recreational water quality in Australia, in-depth case studies provide a comparison of assessment of wastewater reuse feasibility in NSW and Tasmania, communication of information on waters impacted by wastewater in Melbourne, Victoria, and the management of untreated wastewater discharges in Launceston, Tasmania (Figure 1.1). To support each case study, examples are drawn upon including recreational water criteria of the United States Environment Protection Agency (US EPA), frameworks for research and regulatory collaboration in California (USA), and proposed laws for management of combined sewer overflows in New Jersey (USA) (Figure 1.1). The case studies identify deficiencies in the regulation of wastewater disposal. This thesis concludes with a discussion chapter which links the varying themes set out in different chapters, and sets out questions for ongoing research and recommended policy reforms.

The remainder of this chapter is set out in the following manner; Section 2 provides a brief summary of the policy framework in this area including an introduction to current research which is continued in later chapters. Section 3 provides definitions and assumptions used in the thesis. Section 4 presents the aims, hypothesis and describes the objectives and questions used in the thesis. Section 5 provides a brief overview of the research methodology. Section 6 provides a justification for the research. Section 7 provides an outline of the dissertation. Section 8 provides a conclusion to the chapter.

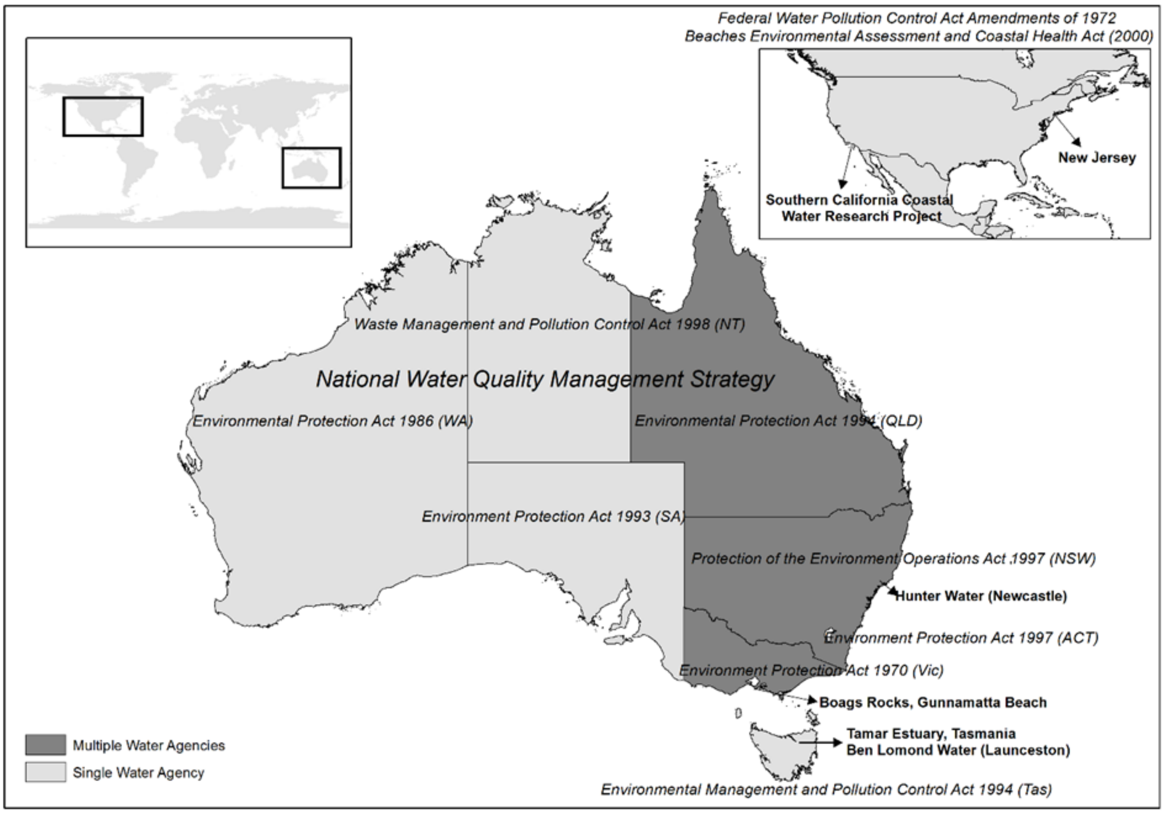

Figure 1.1: Map of case study areas (Launceston (Tasmania), Gunnamatta (Victoria), Hunter region (NSW), New Jersey and Southern California (USA)). Showing principal legislation or guideline for management of wastewater disposal and number of water authorities in each area

2.2 Policy framework

2.2.1 Wastewater disposal in Australia

In 2005, when Australia was in the grip of its millennium drought a Parliament of Australia research brief identified the need to realise the potential of recycled water to ensure economically viable wastewater reuse options are carried out *ex ante* disposal as one of Australia's most pressing issues (Dimitriadis 2005). Despite increased demand for alternative sources of water and national reforms of urban water management, the utilization of wastewater as a resource continues to present a multidisciplinary policy challenge. Even when combined with waste minimization and water conservation policies, the majority of wastewater in Australia is still discharged to marine or freshwater environments (Whiteoak et al. 2012).

The primary alternative to wastewater disposal is to recycle or reuse it. At its simplest level this may simply involve some level of treatment followed by land application of wastewater to support growing of crops for agriculture or other purposes (Agriculture and Resource Management Council of Australia and New Zealand & Australian and New Zealand Environment and Conservation Council 1997). Uses of recycled water increase with treatment, the highest of which is treatment to a standard for safe human consumption, capable of entering the domestic supply system in place of drinking water. Substitution of wastewater in place of traditional sources of water may have broad benefits for society including decreased impacts on environmental values and recreational uses of water through decreased pollution (Anderson 2003). However, the costs and benefits of wastewater reuse vary, leading to calls for case by case assessment of costs and benefits (Marsden and Pickering 2006), as described in Section 1.3 below.

Although Australian water cycle governance has recently begun to shift away from end of pipe solutions to waste management, wastewater reuse on a scale that approaches levels of consumption is still far from being realised. Australia set a national target for wastewater recycling at 30 per cent by 2015. However, volumes of reuse of wastewater in 2009-2010 were 16.8 per cent, this is summarised as follows;

> Volumetrically, the largest volumes recycled are in the states with the largest populations − Victoria, New South Wales and Queensland. However, South Australia reuses the highest proportion of wastewater at 28 per cent, followed by Victoria (24 per cent) and Queensland (24 per cent). Tasmania and the Northern Territory recycled the least by both volume and proportion, facing the lowest demand and abundant potable supplies in most of their major centers (Whiteoak et al. 2012).

Table 1.1 presents the percentages of recycling in 2009 and 2010 presented in the ‘Progress against the national target of 30% of Australia’s wastewater being recycled by 2015’ report (Whiteoak et al. 2012). Overall the nation was achieving a 16.8 percent rate of recycling.

Table 1.1: Wastewater recycling for each jurisdiction in 2009/2010 (Whiteoak et al. 2012)

Jurisdiction	Percent recycled
ACT	13.3
Australia (All)	16.8
NSW	9.8
Northern Territory	6.0
Queensland	23.7

South Australia	28.1
Tasmania	6.2
Victoria	24.1
Western Australia	12.0

A fundamental principle of managing wastewater discharges within national water quality policies is to maintain environmental values of the water; that is, to manage discharge in a manner which takes into account the beneficial values that water provides to society (ANZECC & ARMCANZ 1997). Even though jurisdictions have managed to lower the environmental impact of urban wastewater management, in the past 20 years, anthropogenic inputs into the ocean and surface waters have still increased, with more coastal facilities reporting emissions, increasing population and urban reliance on coastal areas which could have serious consequences for marine and ecological environments (Beeton et al. 2006). Disposal of wastewater relies on the ability of the marine or freshwater environment to effectively dilute pollutants and therefore avoid negatively impacting environmental values. The Australian Guidelines for Sewerage Systems - Effluent Management describe the function of wastewater discharges as follows;

> Many discharges are designed to take account of naturally occurring dilution and disinfection processes at the discharge site, thus providing further protection of the environmental values of the adjoining waters without costly treatment (ANZECC & ARMCANZ 1997, p. 15).

Analysis of the rationale for historical decision making provides important insights into why wastewater treatment infrastructure relies so heavily on wastewater disposal. Beder 1989 examined the political and engineering decisions that resulted in marine outfalls becoming the chosen engineering solution in Sydney (and indeed Australia) for the 25 years that followed. Selection of wastewater outfalls provided what appeared at the time to be a cost effective solution to avoid the costs of treating wastewater and to remove a variety of toxic wastes away from human populations (Beder 1989). This solution relies on the assimilative capacity of the environment to absorb and dilute anthropogenic pollution. Despite the seemingly insidious nature of diverting wastewater to the ocean in order to provide a conduit to disperse toxic and other wastes, wastewater disposal is part of a process of collection and treatment which provides sanitation, and this has provided a better quality of life for many people. Although decisions which may have produced a net benefit to society 30 years ago may no longer be accepted under modern water quality guidelines, the legacy of existing infrastructure may have ongoing implications simply by being in place where alternatives require additional investment.

2.2.2 Australian water quality management and pollution control legislation

Australia's water shortages and inefficiencies have led to national reform of the water industry and integrated management of terrestrial water is an express purpose of Australian terrestrial water policy (Council of Australian Governments (COAG) 2010). The number of water authorities in each Australian state is shown in shaded areas in Figure 1.1. In the USA there is one national agency responsible for water, each state has multiple agencies dealing with water supply, wastewater collection and treatment, and water quality regulation and monitoring. Management of urban water, recycled water and other surface waters in Australia each have legislative regimes set by each State government. Once wastewater is disposed to the marine environment it is no longer terrestrial water and is then governed by pollution control legislation or other environmental control. There are also known inconsistencies between standards that govern on land reuse and those that control marine disposal (Higgins et al. 2004).

The National Water Commission (NWC) has critically commented on regulation of water quality in Australia stating ‘current regulation of water quality, public health and environmental outcomes is not cost-effective and creates barriers to integrated water management’ (NWC 2011, p. viii). In Australia regulation of pollution of water is still primarily driven by State government legislation under which an offence is created for causing environmental harm through polluting (Bates 2010). In order for WWTPs to legally discharge to surface waters, they ordinarily require a licence or permit under that State's environmental legislation. However the command-control model of pollution reduction has been criticised as being over relied upon and ignores other policy solutions providing pollution reduction, such as the role of financial institutions (Richardson 2002). There are no laws which establish statutory causes of action to recover money from polluters who have harmed publically owned natural resources, however there are orders, offences and monetary penalties that courts may impose in order to uphold the polluter pays principle (Preston 2009).

Australia's voluntary national guideline approach to national water quality management is contained in the documents which make up the National Water Quality Management Strategy (NWQMS). The primary document within these considered by this thesis is the National Health Medical Research Council Guidelines for Managing Risk in Recreational Water 2008 (NHMRC 2008). Water quality management in Australia is very much a product of Australia's constitution which does not give the Commonwealth Government power to make laws for recreational or ambient water quality. As a result NWQMS guidelines are non-binding and merely set a benchmark or guidance for states and local officers to adopt and apply according to local circumstances.

2.2.3 Existing research on barriers to integration and efficiency in natural resource management

This section provides a brief overview of work undertaken in various disciplines towards identifying barriers to integrated water management. A review specific to barriers to wastewater reuse is provided in Chapter 2 which provides a summary of barriers to wastewater reuse, and Chapter 4 provides an analysis of the interaction of these barriers to conceal the benefits of wastewater. In its 'Future Directions' report, NWC (2011, p. 25) include impediments to alternative sources of water supply as having 'cumbersome regulatory and approvals processes' as well as 'inadequate evaluation and consideration of the full benefits and costs of IWM options'.

Regulation and institutional factors have been identified as a barrier to integrated water management including (but not limited to) inhibitive costs of producing recycled water, pricing structures which do not allow full costs to be captured, and challenges in streamlining and coordinating regulation and assessment of recycled water (MacDonald & Dyack 2004). Both institutional models and legislation have tended to deal with different aspects of the water cycle in a compartmentalized manner, which may be a barrier to integrated water cycle management (NWC 2007). These inconsistent regulatory standards for water have been observed during the phases of wastewater disposal and wastewater reuse across all jurisdictions in Australia (Higgins et al. 2004).

Significant research has been undertaken under the Australian Water Recycling Centre for Excellence in improving water recycling technologies, improving the evidence base for water recycling guidelines, and to understand and overcome institutional and legal barriers to recycling. For example, significant inroads have been made recently to provide empirical evidence to questions underpinning the assessments of costs and benefits of wastewater reuse, including economic assessment and community willingness to pay for recycled water (Marsden Jacob Associates 2013). In another example, the identification of the impacts of environmental protections for receiving waters as an institutional barrier or driver for investment in treatment has also been considered, for which wastewater reuse may be an option (Institute for Sustainable Futures 2013).

The Productivity Commission (2008) has also made significant contributions to the study of optimal models for the water sector including, the broad impacts of pricing and structure, as well as the efficiency of the urban water sector, and the achievability of integrated water management (Productivity Commission 2011). With adoption of large scale desalination and several large recycling projects, water management in Australian cities has seen a period of state government-driven project selection of large scale water supply projects. Project selection, such as the choice between wastewater recycling or other water supply options involves assessment of multiple factors including an initial assessment that an investment in infrastructure is required (Productivity Commission 2014). Inappropriate or unnecessary investment in desalination plants in many Australian cities may have been caused by avoidable policy and governance aspects, clarity of institutional roles and responsibilities, inadequate options analysis, and notably, the provision of financial subsidies and direct policy prohibitions towards other options (Productivity Commission 2011).

These large augmentation projects appear to have come about through a project selection process driven by the state governments themselves, in many cases with an intense push from government for a particular option to proceed. On the other hand, the majority of individual WWTPs will be either smaller in scale than such projects necessitate, or may fall outside the interest of this larger scale decision making. In 2006 and 2010 Radcliff reviewed the status of water recycling in major Australian cities, the later review finding evidence that some ‘policy bans’ still exist which prohibit planned potable recycling (Radcliffe 2006, Radcliffe 2010). This and other issues have led to the need to reform processes for assessing public infrastructure projects to be described as urgent (Productivity Commission 2014).

Wastewater disposal is generally considered part of the traditional supply network of urban water and sanitation, whereas recycled water projects are often considered as a supply of water from a source which is more expensive to produce than ordinary surface or groundwater. This has led to comparisons of the cost (such as treatment and transport) of recycled water benefits such as attempts to estimate market factors such as demand and consumer willingness to pay. However, due to a lack of consideration of non-market factors, inaccurate water prices were developed, potentially skewing such assessments against reuse or towards lower cost options (Dimitriadis 2005). It is believed that the external costs of wastewater discharge (pollution to the ocean, loss of recreational water resources) are internalized either through environmental licensing and permitting; meaning that environmental externalities would be considered as direct costs of a project to improve a WWTP, or through costs which are avoided, such as no longer meeting discharge requirements (Economic Regulation Authority 2009, Frontier Economics 2011). This however relies on the assumption of the reliability and social desirability of environmental regulation, the subject of further discussion in this thesis.

Perception of risk of recycled water has been highlighted as a barrier to wastewater reuse (MacDonald and Dyack 2004, Nancarrow et al. 2008, Dolnicar & Hurlimann 2010, Dolnicar et al. 2010, Hurlimann and Dolnicar 2010). Higgins et al. (2002) carried out extensive surveys of both users and providers of recycled water. In order to identify the key drivers of self-sufficiency in water supply, Rygaard et al. (2011) examined 113 case studies where water ‘self-sufficiency’ measures have been undertaken. Self-sufficiency was used as a quantifiable means of tracking drivers and barriers that led to water reform in each case study. Several key drivers of water self-sufficiency were identified including direct lack of water, constrained infrastructure, a bias towards particular infrastructure based on spending known as sectoral bias, and lack of water based on policy changes such as maintaining environmental flows to rivers, or desire for water independence.

Another barrier, the thesis addresses, is a lack of integration between land based water and waste management and reform, and marine or freshwater wastewater disposal. Recreational water quality management is a prevalent area of management of waters where wastewater is disposed. An absence of effective regulation and management in recreational waters impacted by wastewater may therefore lead to negative impacts on marine resources by increasing reliance on ocean outfalls where more efficient alternatives exist. This has negative environmental, social and economic consequences for the marine environment (Blackwell 2008), as quantified by Blackwell and Wilcox (2009). Selection of public infrastructure must be done with the principle objective of maintaining the interests and wellbeing of the public (Productivity Commission 2014). This ultimately means greater inclusion of the broader benefits of reduced disposal (Blackwell & Iacovino 2008).

2.3 Definitions of terms

The term wastewater is used to refer to water collected within urban areas for the purpose of transporting to wastewater treatment plants for the purpose of treatment and then disposal or reuse. Sources of urban wastewater generally include liquid waste from households as well as industrial and other liquid wastes in some cases. In the Chapter 7 case study which deals with sewer overflows the term sewage is used to describe water which has been collected but has not been treated at a wastewater treatment plant. A broad definition of wastewater is accepted, although it is important to note that this thesis will consider wastewater that is discharged from regulated wastewater treatment facilities.

Recycled water is defined as wastewater and stormwater which has been treated and diverted away from disposal and, as a result of appropriate treatment, is suitable for beneficial uses (Dimitriadis 2005). In this thesis it refers to treated wastewater produced by an urban water utility and utilized by the utility or a third party for; ‘onsite reuse, agriculture, irrigation, industry, potable or other use external to the treatment process’ (Water Services Association Australia & NWC 2007). In order to ensure consistency with other literature in this area the terms recycled water and reuse water are used interchangeably (Dimitriadis 2005).

This thesis considers two types of wastewater reuse feasibility assessments, one driven by a state government water planning process calling for costs and benefits to be determined for a range of wastewater reuse options for multiple WWTPs. The other process is driven by an environmental regulator under WWTP environmental permitting that requires study of the feasibility of reuse options for each WWTP. It is expected that there will be a range of drivers for assessments as well as approaches depending on local circumstances and needs.

Feasibility assessment of wastewater reuse is used broadly in this thesis to describe the processes involved in decision making on wastewater reuse and recycling schemes. This could involve project selection or may involve the assessment of the costs and benefits of various options for wastewater reuse, such as different applications of wastewater which require different costs of treatment or transport, or may result in differing rates of return. The options themselves may be simple (decision to proceed, site location, technology choice, pricing structures etc.). However there may be complex interactions of social, environmental, economic and even political factors which if not considered, could lead to unnecessary costs to society (Urkiaga et al. 2008). With respect to comparative costs, factors such as geographic location, need for transport, pipes and other factors mean wastewater recycling options are required to be evaluated on a case-by-case basis (Marsden & Pickering 2006).

The National Water Commission ('NWC') states that its 'unambiguous' position on urban water recycling is '….subject to four conditions' which are that:

> 1. [p]rior cost/benefit and risk analyses are conducted which take full account of social and environmental externalities and avoided costs;
>
> 2. the best available science is utilised;
>
> 3. the project is subject to best practice regulatory arrangements (based on the Australian Guidelines for Water Recycling); and
>
> 4. the community participates in decisions to introduce recycling and that subsequent management arrangements are transparent and accountable (National Water Commission 2010, p. 2).

Although there are as yet no national guidelines to assist in the assessment of wastewater reuse costs and benefits; the NWC's position statement on urban water recycling states that the Australian Guidelines for Water Recycling ('AGWR') 'provide an excellent framework for managing safety and guiding responsible decisions' (NWC, 2010, p. 1). The AGWR have been developed under the National Water Quality Management Strategy ('NWQMS'). The guidelines are divided between several aspects of water reuse including, managed aquifer recharge, augmentation of drinking water supplies, managing health and environmental risks, and safe concentrations of chemicals in recycled water. The approach taken to protect human and environmental health is described as a risk management approach (Natural Resource Management Ministerial Council et al. 2006).

The unintended positive or negative consequences of increased pollution on marine resources are known to economists as one of the externalities of wastewater management (Daly & Farley 2011). Externalities themselves are a focus of this thesis. For this thesis the interest is on examining environmental and social benefits or disadvantages of the practice of wastewater management which may or may not be factored into cost benefit analysis for wastewater options assessment.

There are a range of structures for managing urban water in Australia. For the three Australian case studies in this thesis, urban water is managed through a government owned statutory corporation (TasWater Corporation, Hunter Water Corporation, Melbourne Water Corporation). The term ‘water authority’ is therefore used throughout this thesis to recognize that although this structure is common, it is not the only model of urban water services in Australia. That said, the phrase water corporation may be used interchangeably in place of this term.

2.4 Aims, hypothesis and research questions

The primary aims of this thesis are;

> To examine the integration between land based water and wastewater management, the establishment of wastewater reuse schemes, and wastewater disposal in Australia in order to determine whether it is possible to identify and remove any policy or regulatory barriers to wastewater recycling in Australia.

In doing so, this thesis aims to provide insight into aspects of Australian water and environmental legislation and practice which may be acting as a barrier to policies that promote efficient lifecycle management of wastewater. A central theme of the thesis is whether recreational water quality management is optimal and if not, what steps should be taken to rectify this situation.

This thesis therefore poses the following hypothesis:

> Management of the external impacts of wastewater disposal in Australia is currently not optimal and this creates a barrier to wastewater reuse and extends to broader consequences for the marine and coastal environment.

This thesis accumulates evidence for and against this hypothesis by considering the following additional research questions:

1. *How do wastewater and water quality management approaches between jurisdictions compare, including local, state or territory, national and international standards? (Chapter 2)*
2. *What methods are currently used to address the feasibility of wastewater reuse and what factors are known to impact these, including environmental regulation? (Chapters 3, 4)*
3. *Do urban water quality governance structures and economic regulation of water industry influence the ability to consider environmental externalities of wastewater treatment? (Chapters 2, 3, 4)*

4. *Using recreational water quality management as an area of regulation of external impacts of wastewater disposal, does governance of wastewater disposal in Australia impact decision making on the establishment wastewater reuse schemes? (Chapters 5, 6, 7).*
5. *For the purposes of willingness to pay, do swimmers and other recreational users gain a fair appraisal of the impacts of wastewater disposal by relying on communication of recreational water quality? (Chapters 4, 5, 6, 7)*
6. *Does Australian environmental regulation (through recreational water quality testing and monitoring) provide an accurate representation of the external impacts of wastewater disposal? (Chapters 5, 6, 7, 8)*
7. *Are recreational water quality guidelines applied consistently across Australia? (Chapters 5, 6, 7)*
8. *How well do Australian water quality guidelines meet their own objectives and serve the public in 'worst case scenario' situations of untreated effluent discharges to recreational waters? (Chapters 6, 7)*
9. *Are there better approaches to water quality communication which can be learnt from other jurisdictions? (Chapters 5, 6, 7)*
10. *Does the lack of communication of externalities produce problems with the use of willingness to pay for recycled water as a factor in the assessment of wastewater reuse and disposal options? (Chapters 5, 6, 7, 8)*
11. *Does recreational water quality management present new barriers to efficient wastewater reuse in Australia, not previously considered, and are there opportunities to improve? (Chapters 2, 3, 4, 5, 6, 7, 8)*

2.5 Methods

In order to answer the above research questions a number of methods were employed. Following a legislative and policy review included in Chapter 2, a series of case studies were chosen based on the factors listed in Table 1.2. The Tasmanian case study is returned to in Chapters 2 and 3 which examine institutional barriers to wastewater reuse, as well as in Chapter 8 which examines environmental regulation of externalities of wastewater disposal. Tasmania was selected as an appropriate case study due to recent water and sewage industry reforms, which included changes to environmental management and also because the state does not have water scarcity, leaving environmental regulation as the primary driver for wastewater reuse, and relative lack of progress for wastewater recycling. This same lack of water scarcity was also present in the NSW Hunter region case study. Due to the high variability of wastewater governance and specific circumstances impacting these assessments the recurrent focus on Tasmania allows more specificity when reforms are proposed in later chapters, in contrast to the broad brush painted in early literature into barriers to wastewater reuse.

Table 1.2: Factors leading to selection of major and minor case studies presented in this thesis

Authority	Location	Justification
TasWater Corporation	Launceston, Tasmania	Regional water authority, may have different challenges to well-studied large authorities in capital cities Recent water governance restructure in Tasmania Facing significant challenges in meeting water quality guidelines and objectives Presence of untreated effluent discharges from CSO into secondary contact recreation area
Hunter Water Corporation	Hunter Valley, New South Wales	Historical ecosystem health issues in receiving waters Regional water authority with comparable water quality issues but has been in existence longer than TasWater Different environmental regulation creates contrast for comparison to Tasmanian reuse feasibility assessment
Melbourne Water	Melbourne, Victoria	Historical management of wastewater outfall in presence of primary contact recreation Upgrade of WWTP driven by recreation and environmental impacts of outfall Highly studied outfall with respect to marine and recreational impacts Incongruence between claims of public, media, water authority, regulators and government
USA	Orange County, California, USA	Presence of Southern California Coastal Water Research Project as established cooperative approach to water quality research US Environment Protection Authority Recreational Water Criteria 2012 present novel techniques of relevance to Australian beach water quality management programs
USA	New Jersey, USA	Use of CSOs has been a historical issue for water quality management Presence of relevant bill (proposed law before state legislature) which would provide additional reporting requirements for combined sewer overflows

The case study analysis in Chapters 3 and 4 of the thesis focuses on governance and legislation. Chapter 3 analyses the background to wastewater reuse upgrades in Tasmania. The recentness of these reforms provided information on the motivations and drivers for reform, and how these impact wastewater management. Chapter 4 on the other hand focuses on the interaction of environmental legislation and management with wastewater reuse feasibility assessment.

The analysis of recreational water in Chapter 5 involves collecting guidelines from each jurisdiction and comparing elements including communication and microbiological limits with those contained in NHMRC 2008 guidelines. US recreational water criteria are discussed in this chapter in order to provide a context for the assessment of the modernity of Australian practice. US experience and practice is referred back to within the reform section of this chapter which proposes novel policy reforms for overcoming constitutional issues with Australian water quality management.

In addition to the analysis of the case studies in earlier chapters, Chapters 6 and 7 provide examples of the management of recreational water environments where there is an identified need for wastewater treatment upgrade. These chapters provide information on the weaknesses and strengths of water quality guidelines and regulation. These case studies were also selected based on the presence of recreational waters in conjunction with wastewater discharge, and the availability of evidence and debate, which was deemed necessary in order to carry out this review.

Chapter 6 provides a review of scientific understanding of the marine environmental and human health impacts of wastewater discharge from one outfall, as well as the resulting public debate and coverage of statements from citizens and water authority representatives in the media. The chapter notes that this approach is limited as a scientific method because it does not confirm or deny the public claims of recreational water illness made in the newspaper articles. However, more importantly, it does allow a picture to be presented of communication of recreational water quality in response to claims by members of the public.

Chapter 7 examines the management of water quality where untreated sewage and stormwater are discharged. Within this chapter, the analysis of Roberts and Craig (2014) is used to assess regulatory effectiveness of water quality management in Tasmania. This involves examining legislation under categories of clarity of objectives, clarity of legal interpretation, clarity of institutional responsibilities, and strength of enforcement powers. This approach was chosen because Roberts and Craig (2014) used it to analyse similar environment protection policies in Victoria, offering a useful point of comparison.

In order to support the case studies informal interviews were conducted with Tasmania's state health regulator, local government environmental health departments, the state economic regulator, the Tasmanian water corporation, TasWater, and an NGO in the US. A Human Research and Animal Ethics approval was obtained from the University of Tasmania. Under this an email was sent to participants explaining the information that would be recorded, this included names of organisations but not personal details or names. These interviews often involved discussing the application of publicly available documents and where possible this thesis refers to the primary source referred to by the interviewee. These interviews were supported with informal conversations, meetings and industry involvement throughout the thesis supported by involvement in Water Research Australia. This included visits to Beaconsfield WWTP, Hunter Water WWTPs in NSW, and Gunnamatta outfall in Victoria (Figure 1.1).

2.6 Justification

Regulatory reforms must be made with knowledge of the effectiveness of current governance structures and the policy requirement to factor in the externalities of water management into decision making (COAG 2010, Clause 73). Decision making on wastewater reuse is undertaken around Australia for WWTPs ranging from very small to very large. For this reason the identification and analysis of factors which may decrease the ability of such processes to account for the range of social, environmental and economic impacts is necessary and valuable.

This PhD differentiates itself from existing studies on barriers to wastewater reuse because, whereas other studies examine processes encountered delivering in specific schemes, this thesis examines the extent to which current environmental regulations manage the negative or positive externalities of wastewater disposal. This is done to question the extent to which performance indicators (like regulatory compliance or recreational water monitoring results) can be relied upon that represent the economic and other costs of continuing to discharge wastewater, compared to reducing discharge through wastewater reuse. In summary, it provides a review of environmental legislation, policy and practices and describes their interaction with assessment of wastewater reuse schemes. This PhD builds upon existing research into institutional barriers by exploring one possible barrier in detail in order that specific and implementable reforms can be sought.

Information availability impacts public perception of alternative water sources (Dolnicar et al. 2010). It also impacts decision making for whether people choose to use a swimming or recreation site (Vesterinen et al. 2010). The choice of recreational water quality management as an area of study for environmental impact of wastewater disposal was based on several factors; 1) it is the primary level of human interaction with wastewater disposal impacts, the opening or closing of a recreation area is a key example of social and environmental impact of disposal; 2) when people are being surveyed or expected to pay for wastewater reuse in order to inform project selection, it is important to understand what information they have access to, for example, whether beaches are opened or closed, and if this is based on consistent factors; 3) although ambient monitoring of receiving waters is potentially a larger area of regulation, the impacts on marine species may be hard to define or out of sight for people making choices in willingness to pay; and 4) whereas environmental standards for wastewater disposal are contained in diverse and hard to access documents (licences set for individual wastewater discharges), recreational water practices and policies are more readily determined and available.

Recreational water regulation therefore provides an ideal but often overlooked platform for studying the environmental management of wastewater for the study of the efficiency of regulation.

Assessment of the economic costs and benefits for wastewater recycling assumes that environmental legislation of wastewater disposal is socially optimal and therefore the external impacts of reduced wastewater disposal are internalized as avoided costs of regulatory compliance (Economic Regulation Authority 2009, Frontier Economics 2011, Marsden Jacob Associates 2013). It is crucial that this assumption is accurate, particularly since it can result in rejection of reuse projects and therefore greater or continued reliance on disposal. Further, Higgins et al. (2004) showed a disparity between disposal regulation and recycled water guidelines; indicating that the assumption that environmental guidelines reflect optional social conditions requires investigation.

In addition to new information for wastewater management, a review of recreational water guidelines in Australia provides new knowledge to allow suggested reforms for human health and safety (Figure 1.2). Human contact with wastewater in water at recreational sites can lead to important public health implications, with recreational water illnesses such as gastroenteritis, upper respiratory infections and skin infections, amongst other less common illnesses, shown in Figure 1.2 (NHMRC 2008).

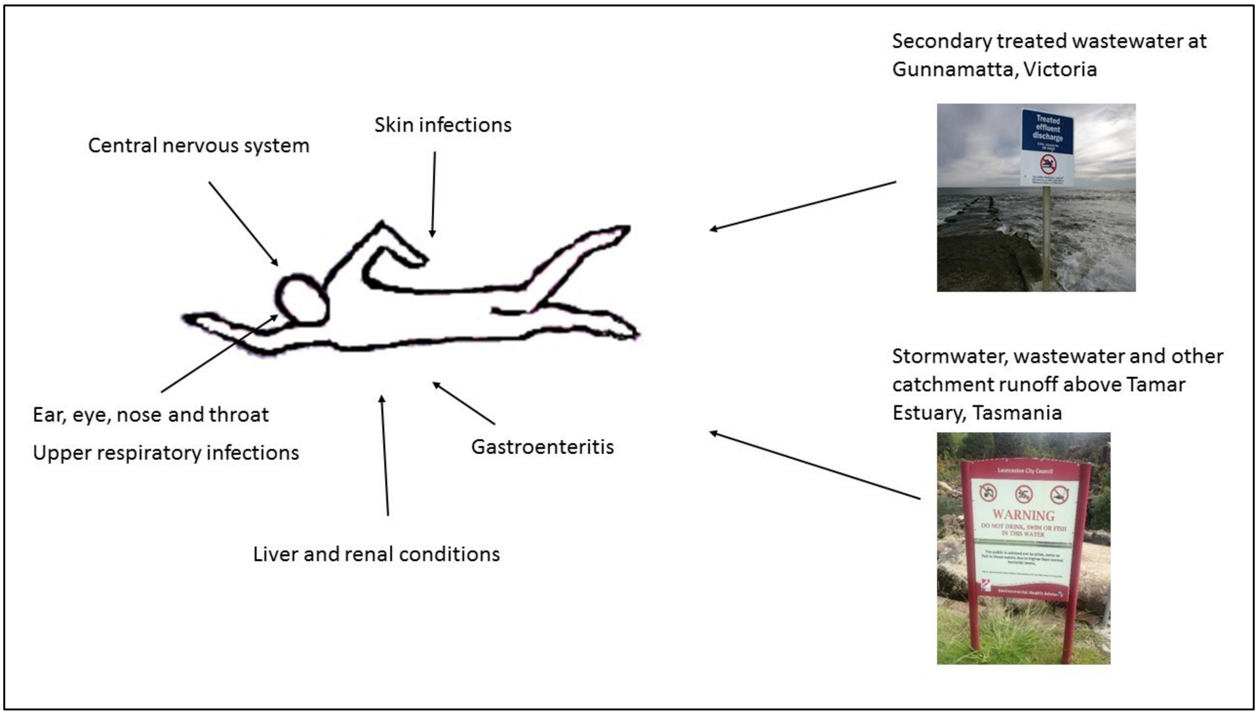

Figure 1.2: Recreational water illnesses which can result from exposure to polluted water and described in National Health and Medical Research Council 2008, Guidelines for Managing Risks in Recreational Water (NHMRC 2008), and sources of microbial water pollution described in Gunnamatta (Victoria) and the Tamar Estuary (Tasmania).

Further, at a local and regional scale, Chapters 3, 4 and 5, 7 describe deficiencies, reforms and improvements to a Tasmania's previously inadequate management of human impacts on water and the associated costs to society. Together these chapters provide timely new-knowledge and in-depth independent analysis which is valuable current and the ongoing reform process in Tasmania.

2.7 Outline of the dissertation

This thesis will examine known barriers to increasing water reuse and the level of integration between governance 'on land' and environmental regulation in once wastewater is disposed to the environment, two distinct phases of the Australian water cycle.

There are three parts and eight chapters in this thesis, the case studies used in each part is presented in Table 1.3; Part 1 provides a background to wastewater pollution in Australia (Chapter 2) by reviewing Australian legislation, policies and guidelines and describes the governance structure of water quality and wastewater management. Part 2 (Chapters 3 and 4) examines the feasibility assessment of wastewater reuse by providing two case studies which highlight novel features of governance and legislation with relevance to the environmental externalities of wastewater management. Part 3 (Chapters 5, 6 and 7) outlines the legislation, guidelines and practice for the management of recreational water in Australia. The latter two chapters provide in-depth case studies highlighting inadequacies within the system of recreational water management by discussing jurisdictional experience outside Australia. In addition, not included in Table 1.3 are two smaller US case studies referred to in Chapters 5 and 7, which are described in Table 1.2.

Table 1.3: Overview of the contribution of individual case studies to the broad themes of <u>disposal regulation</u>, <u>reuse feasibility assessment</u> and <u>recreational water quality</u>

Themes	1. Wastewater disposal legislation and water quality guidelines (Chapters 2 & 3)	2. Assessment of wastewater reuse feasibility (Chapters 3 & 4)	3. Recreational water quality (Chapters 5, 6 and 7)
Approach	Legislative review: Australia (national guidelines)		Review of legislation, guidelines, practice: (National, ACT, NSW, Northern Territory, Queensland, South Australia, Tasmania, Victoria, Western Australia) In depth case studies:
	Tasmania	TasWater (formerly Ben Lomond Water) (Tasmania)	TasWater 'Combined Sewer Overflow' (Launceston Tasmania)
	Victoria		Melbourne Water 'South East Outfall' (Victoria)
	NSW	Hunter Water (NSW)	

Although this thesis covers a broad range of topics, convergent themes that are returned to across the thesis are barriers to wastewater reuse, and inadequate environmental management of wastewater disposal (including recreation). A review of literature on the barriers to wastewater reuse is provided in Chapter 2. In Chapter 3 governance structures within Tasmania which have driven underinvestment and therefore may act as barriers to integration are described. In Chapter 3 barriers to wastewater reuse are described with respect to their impact on assessment of wastewater reuse feasibility.

Chapter 2 of this thesis is a review and discussion of legislation and guidelines in Australian jurisdictions. This review focuses on water quality guidelines and water industry structure. In order to do this it will identify relevant pollution and water quality guidelines and legislation. Chapter 3 and Chapter 4 focus on wastewater reuse feasibility assessment. Chapter 3 has a focus on water and sewage management and governance structures. TasWater Corporation in Tasmania (formerly Ben Lomond Water Corporation) is a recently-formed water and sewage corporation. The historical issues for water and sewage management are contrasted against the need to assess every WWTP for the feasibility of wastewater reuse in an area where water scarcity is not an issue.

In Chapter 4, the assessment discussed in Chapter 3 is compared to a much larger state government-driven assessment conducted for Hunter Water Corporation in NSW. Within this Chapter, the discussion of barriers to wastewater reuse focuses on their impact on wastewater reuse feasibility assessments. It identifies an assumption used within the economic literature and assessment of willingness to pay for recycled water, that environmental regulation in Australia is effective. This has implications for how the external impacts of wastewater disposal are considered when various options are compared. This leads the thesis to consider the environmental regulation of wastewater disposal through Chapters 5, 6, and 7. Following the review of recreational water management practice in Australia (Chapter 5), the subsequent chapters provide more detail showing the real world application of environmental guidelines in areas where wastewater disposal causes problems for humans through water-based recreation.

Finally, Chapter 8 discusses the impact of regulation of environmental impacts of wastewater on efficient wastewater management and the policy mechanisms that have been proposed to deal with these deficiencies. It also raises the question as to whether environmental management is sub-optimal, in particular, the communication of environmental externalities, could this also produce problems for assessment of willingness to pay for recycled water?

2.8 Summary and conclusion

By combining the study of institutional barriers to wastewater reuse (through examining the assessment of wastewater reuse feasibility) with an appraisal of the regulatory effectiveness of environmental regulation of wastewater disposal, this thesis identifies and analyses factors which may impact technology choices, as well as environmental regulations, which may impact how the externalities of wastewater disposal are accounted for in decision making. Deficiencies in environmental management have implications for public health and environmental impacts which produces negative outcomes for humans and the environment. This necessitates an analysis of recreational water quality management. By discovering weaknesses in recreational water quality management, the thesis is able to outline reforms which may overcome weaknesses within Australian water quality guidelines. Perhaps more central to the theme of the thesis, the thesis concludes that where recreational water quality communication or environmental management is not optimal, this may alter the outcomes of wastewater reuse feasibility assessments. This is presented as an overlooked barrier to wastewater reuse, the study of which allows for removal of incorrect assumptions which ultimately will lead to better decision making.

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Details of publication of Chapter 2, Section 2.4

Section 2.4 of this chapter was presented as a section of a conference paper at the 2012 Australia and New Zealand Society of Ecological Economics Conference. The information in this section is also summarised in Chapter 4, Section 4.4. Details of authors and their contribution can be found in the opening pages of this thesis.

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3 Policy framework for disposal of wastewater to surface waters

3.1 Introduction

This chapter provides a background into environmental laws and policies regulating wastewater disposal in Australia. Wastewater disposal to the marine and freshwaters is regulated separately in each Australian jurisdiction. In general WWTPs are operated under a licence or permit issued in accordance with state environmental legislation. The Commonwealth Government has played its central role as the formulator of water quality guidelines.

Australia's Constitution lists powers of the Commonwealth Government, meaning it can make laws for only certain affairs. Since water management is not listed as a federal power the Commonwealth can either seek an intergovernmental agreement from the states whereby the commonwealth, state and local governments meet through the Council of Australian Governments (COAG) and agree to pass legislation to take a consistent approach or establish guidelines. The Commonwealth Government produces water quality guidelines, while local application of these guidelines and management of point source marine pollution from WWTPs continues to be carried out by the states and local governments (Bates 2010).

The first section of this chapter introduces the Australian policy and regulatory regime for the disposal of wastewater and the protection of water quality. It briefly outlines national policies which establish the benchmark for how urban water and water quality are managed. Different approaches have been taken for water management (described in Section 2.1) compared to water quality management which is set through guidelines applied by states (described in Section 2.2). National guidelines have been also been established covering water quality for recreational waters.

The second section of this chapter provides an overview of environmental protection legislation under which wastewater is disposed to marine and freshwater in Tasmania, New South Wales (NSW) and Victoria in order to set the stage for more focused analysis in later chapters of this thesis. Although differences between how these jurisdictions apply national water quality guidelines are noted throughout this thesis, similarities described in this chapter include the use of environmental protection legislation to prohibit causing environmental harm by discharging pollution to water. Recreational water management by these jurisdictions is examined briefly here and returned to in greater detail in Chapter 5 of this thesis.

Next, a discussion of mixing zones is included. Mixing zones are areas surrounding a wastewater discharge where water quality protections are not applied. This is relevant to this thesis because the differential application of these areas allows different levels of external impact from wastewater to be considered as compliant with environmental regulation. Finally, a review of literature on barriers to wastewater reuse is presented.

3.2 Overview of the legal regime for wastewater disposal in Australia

3.2.1 National Water Initiative (NWI)

In 2004 the COAG agreed on the Intergovernmental Agreement on a National Water Initiative (‘NWI’). This agreement focused on ensuring water management would undergo a uniform national reform process. The objectives and elements of the 2004 NWI included (but were not limited to) access to water, planning and management, urban water governance, water markets, accounting, trading and pricing, recognising that surface and groundwater resources are connected, and planning for environmental and public benefits through integrated management of environmental water (Council of Australian Governments (COAG) 2010). Section 7 of the *National Water Commission Act 2004* (Cth) initially gave the National Water Commission (NWC) general functions in implementing the NWI, making recommendations on water management issues to the Commonwealth Government, assessing Australia’s water resources and producing biennial assessments of the implementation of the NWI.

Variation still remains between the structures of various jurisdictions’ water authorities, as reflected by the number of authorities providing water and sewage services in each jurisdiction. NSW, Victoria and Queensland have a multiple water authorities, while Tasmania and South Australia, ACT, Northern Territory and Western Australia have just one each. Although within NSW two large water corporations Sydney Water and Hunter Water provide water and wastewater services within the Sydney and Newcastle cities and surrounding suburbs. In addition, some areas are serviced by local governments, such as outside of the management areas of Sydney Water and Hunter Water in NSW, and outside of South East Queensland. Generally, where water authorities provide these services the model is to provide both water and sanitation, charge for these services, then to provide a dividend payment to government owners based on economic and pricing principles set by the state.

3.2.2 National Environment Protection Measures (NEPMs)

The Intergovernmental Agreement on the Environment (1992) (IGAE) was an agreement between the Commonwealth Government and the states and territories of Australia which defined the roles and responsibilities of the parties to the agreement with respect to environment protection (COAG 1992). As a result of the IGAE the Commonwealth Government passed the *National Environment Protection Council Act 1994* (Cth) which established a National Environment Protection Council (NEPC). Legislation was later introduced by the states and territories in order to implement the National Pollutant Inventory (NPI) and National Environment Protection Measures (NEPMs), which are standards, guidelines and goals and protocols which attempt to harmonise pollution standards across Australia (Bates, 2010). Each state has passed legislation to implement these measures, in the case study jurisdictions through the *National Environment Protection Council Act 1994* (Cth), *National Environment Protection Council (New South Wales) Act 1995* (NSW), *National Environment Protection Council (Victoria) Act 1995* (Vic), and *National Environment Protection Council (Tasmania) Act 1995* (Tas). Section 14(1) of the *National Environment Protection Council Act 1994* (Cth) presents a list of matters which the NEPC may make NEPMs for. NEPMs can be distinguished from the water quality guidelines (discussed in Section 2.3 of this chapter) because they can be legislative measures (*National Environment Protection Council Act* s. 21). NEPMs have not been set for water quality and national guidelines for water quality are discussed in Section 2.3 of this chapter.

The National Environment Protection (National Pollutant Inventory) Measure (1998) (NPI) is a centrally driven pollution monitoring and information collection measure. Where a WWTP emits a substance listed under the NPI in excess of the threshold amounts for prescribed pollutants it is required to report to the NPI. States and local governments report the annual emitted volumes of listed substances under the NPI and this data is then available online through the Australian Government NPI website (Australian Government Department of the Environment 2014a).

3.2.3 The National Water Quality Management Strategy ('NWQMS')

The Commonwealth has carried outs its role of coordinating water quality standards through development of the NWQMS. The aim of the NWQMS is to achieve sustainable use of Australia's water resources through:

> A nationally consistent approach to water quality management will be achieved through the development of high-status national guidelines which can provide the point of reference when issues are being determined on a case-by-case basis. The adoption of national guidelines provides a shared national objective while allowing flexibility to respond to differing circumstances at regional and local levels. The management process provides for a consistent approach to the implementation of the strategy while recognising differing political, social and natural conditions (Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand 1994, p.vi).

Unlike NEPMs the NWQMS guidelines are not legislative instruments. They create no mandatory requirements. They are not intended to be used as a set of criteria providing limits for water quality. The guidelines component of the NWQMS consists of a series of documents under the headings; 1) water quality benchmarks which include drinking water, recreational water, water quality monitoring and reporting; 2) groundwater protection guidelines; 3) diffuse and point sources pollution guidelines which cover rural land uses and stormwater management; 4) guidelines for sewerage systems including effluent management, trade waste, biosolids, reclaimed water use and overflows; 5) effluent management guidelines which have been made for various agricultural practices; and finally 6) Australian guidelines for water recycling. In addition there are several additional water quality publications, reviews, discussion papers and a set of guidelines for the management of acid sulphate soils in inland aquatic ecosystems (Australian Government Department of the Environment 2014b).

NWQMS Paper 4 is referred to as the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines) (ANZECC & ARMCANZ, 2000b, vol. 1). The ANZECC Guidelines contains seven chapters, elements of which have been replaced by later guidelines to reflect more recent scientific evidence, this includes the recreational guidelines which were replaced in 2008 and are discussed in Section 2.4 of this chapter.

The ANZECC guidelines provide a methodology for State and local water quality managers to establish the level of protection required for a body of water based on environmental values, as well as allowing them to establish monitoring programs which gather scientific knowledge to allow development of guidelines, decision making criteria, objectives and water quality indicators based on local circumstances, and use this framework and information to apply appropriate management responses (ANZECC & ARMCANZ 1994). Stakeholders and the community should be involved and consulted in the process of determining water quality objectives (ANZECC & ARMCANZ 1994).

Key terms within NWQMS are environmental values, objectives and guidelines. Environmental values (also called beneficial uses or protected environmental values) are defined within the NWQMS as:

> [P]articular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits (ANZECC & ARMCANZ 2000b, vol. 1, p. 2-6).

Environmental values are applied to individual waterbodies by states. For the environmental value of recreation many states include primary or secondary contact recreation. These are defined differently in various states however as an example; primary contact recreation may involve full body immersion for example, swimming. Whereas secondary contact recreation involves partial contact such as splashing of the arms and body, for example, jet skiing, kayaking and sailing (Healthy Waterplay 2014). The process of setting environmental values is followed by the establishment of management goals which contain details of what protection is required to maintain environmental values (ANZECC & ARMCANZ 2000b, vol. 1).

The ANZECC guidelines define water quality guidelines as '…a numerical concentration limit or narrative statement recommended to support and maintain a designated water use.' (ANZECC & ARMCANZ 2000b, , vol. 1, p. 2-9). Water quality guidelines contain the actual physical parameters that would need to be maintained to uphold environmental values or meet management goals.

Australian guidelines moved away from ‘trigger’ values under which a single Australia-wide limit is set for a parameter above which action is triggered, and towards a risk management approach and the concept of applying different values in different circumstances (ANZECC & ARMCANZ 2000b, vol. 1). This is reflected in the national recreational water guidelines which do not set universal daily values for microbial pollution, discussed in Section 2.3 of this Chapter. Although note there has been a move towards trigger values in recreational water management, discussed in Chapter 5.

A further key concept of Australian water guidelines are objectives, which are defined as; ‘...the specific water quality targets agreed between stakeholders, or set by local jurisdictions, that become the indicators of management performance’ (ANZECC & ARMCANZ 2000b, vol. 1, p. 2-11). Whereas water quality guidelines such as ANZECC 2000 recommend limits for various measurements of water quality, for a body of water a State would include specific numerical concentrations or limits within water quality objectives (ANZECC & ARMCANZ 2000b, vol. 1).

3.2.4 National Health Medical Research Council Recreational Water Quality Guidelines

Within the NWQMS recreational water quality is covered within the National Health and Medical Research Council Guidelines for Recreational Water Quality and Aesthetics ('NHMRC 2008 Guidelines'). These are used in place of former ANZECC Guidelines Chapter 5 which relied on numerical limits based on a percentage of samples exceeding a limit.

The method of measuring risk of microbiological contamination used within the NHMRC 2008 Guidelines is the use of sanitary inspection categories in conjunction with microbial water quality assessment. Microbial water quality assessment is necessary because of the connection between the presence of human faecal material in recreational water to human illness. They therefore recommend states take water samples and test these for the presence of faecal indicator bacteria (FIB). The FIB chosen within NHMRC 2008 for both fresh and marine water is the organism *enterococci*. FIB are organisms found in the digestive tracts of mammals, they may not necessarily be harmful themselves but are used to indicate the presence of faecal matter and therefore other harmful pathogens.

The NHMRC 2008 guidelines introduce a three level alert system for monitoring hazards to recreation, these are surveillance mode (green), alert mode (amber), and finally action mode (red). Green is simply normal conditions requiring normal sampling following the guidelines, amber is used where there are elevated levels of some contaminant and therefore this requires investigation, and red where the water is unsuitable for recreation and therefore public warnings should be issued.

The application of NHMRC Guidelines and ANZECC Guidelines at the State, Territory and local government level appears to vary considerably. This is the subject of Chapters 5, 6, and 7 of this thesis. Table 2.1 provides an overview of environmental protection legislation in Australia and recreational water quality guidelines.

Table 2.1: Overview of legislation or policies for Australian jurisdictions[2]

Jurisdiction	Environment protection	Recreational water quality
ACT	*Environment Protection Act 1997* (ACT)	ACT Guidelines for Recreational Water Quality (2010) (ACT Government Health 2010)
Commonwealth	National Water Quality Management Strategy[a]	National Health Medical Research Council Guidelines for Managing Risks in Recreational Water 2008 (NHMRC 2008)
NSW	*Protection of the Environment Operations Act 1997* (NSW)	Marine Water Quality Objectives for NSW ocean waters (NSW) (Department of Environment and Conservation (NSW) 2005)
Northern Territory	*Waste Management and Pollution Control Act 1998* (NT)	Guidance Notes for Recreational Water Quality in the Northern Territory (Northern Territory Department of Health 2011)
Queensland	*Environmental Protection Act 1994* (QLD)	Queensland Water Quality Guidelines 2006 (Queensland Government Department of Environment and Heritage Protection 2009)
South Australia	*Environment Protection Act 1993* (SA)	South Australia Environment Protection (Water Quality) Policy 2003(South Australian Government 2003)
Tasmania	*Environmental Management and Pollution Control Act 1994* (Tas)	Tasmania Recreational Water Guidelines 2007 (Tasmanian Government Department of Health and Human Services 2007)
Victoria	*Environment Protection Act 1970* (Vic)	State Environment Protection Policy (Waters of Victoria) 2003 (EPA Victoria 2003)
Western Australia	*Environmental Protection Act 1986* (WA)	Microbial Quality of Recreational Water Guidance Notes (Department of Health and The University of Western Australia 2007)

a. NWQMS provide non-binding guidelines for water quality management as described above

Table 2.1 shows that ACT, Northern Territory, Tasmania and Western Australia have guidelines or guidance notes specific to recreational water. By contrast other states may provide limits or guidance for recreational waters within general water quality policies or objectives. Furthermore, Western Australia and the Northern Territory are the only states whose recreational water guidance notes apply

[2] Where no guidelines exist jurisdiction relies on Commonwealth guideline unless otherwise indicated. Where possible the most relevant jurisdiction-wide guideline has been listed.

NHMRC 2008 to their local context. For this reason these jurisdictions do not have their own recreational water guidelines. Note that the NSW Beachwatch program does not recommend the Marine Water Quality Objectives for NSW ocean waters (NSW). The recommended program is discussed in Chapter 5.

3.3 Wastewater disposal legislation in Tasmania, New South Wales (NSW) and Victoria

3.3.1 Tasmania

3.3.1.1 Discharge licensing and environmental monitoring

Environmental Management and Pollution Control Act 1994 (Tas) (Tasmanian EMPC Act) Sections 12 and 13 establishes the Environment Protection Authority (Tasmanian EPA) and Environment Protection Board. The EMPC Act s. 50, 51 and 51A creates the penalties for the offences of causing serious environmental harm, material environmental harm, or to deposit pollutants where environmental harm might reasonably be expected to be caused.

The Tasmanian EMPC Act defines three levels of activity; the Tasmanian EPA is only responsible for reviewing Level 2 activities. Level 2 activities include facilities that discharge sewage, septic tank effluent or industrial or commercial wastewater to both land and water with a design capacity of more than 100 kl a day (EMPC Act Schedule 2). The EPA may then require environmental performance conditions to be contained in the WWTP's permit (EMPC Act s. 24). There are 84 of these facilities in Tasmania and an unknown number of smaller Level 1 facilities controlled by councils (Environment Protection Authority (Tasmania) 2014).

There is some level of integration between the various legislative regimes. If a proposal is made under the *Land Use Planning and Approvals Act 1993* (Tas) for a Level 1 activity, it may be required to be referred to the EPA board (EMPC Act s. 24). If a planning permit proposal is made under the *Land Use Planning and Approvals Act 1993* (Tas) for a Level 2 activity, it must be referred to the EPA board for an assessment (EMPC Act s. 25). If a person proposes a Level 2 activity and is not required to obtain a permit under the *Land Use Planning and Approvals Act 1993* (Tas) then they must also refer the proposal to the Tasmanian EPA Board for an assessment under the (EMPC Act s. 27). Level 3 activities are also declared under the *State Policies and Projects Act 1993* (Tas) and may be required to undergo an integrated assessment.

3.3.1.2 Guidelines and objectives for discharges in Tasmania

Tasmanian water quality objectives are contained in the State Policy on Water Quality Management 1997 ('SPWQM'). The Tasmanian SPWQM sets the objectives upon which resource and planning decisions that impact surface waters in Tasmania are made. The values decision makers must choose from distinguish surface waters ecosystems and coastal waters ecosystems. Recreational water quality and aesthetics includes primary contact, secondary contact and aesthetics. Once environmental values are set they are displayed publically, and are incorporated into planning schemes, as well as catchment management mechanisms. The Tasmanian SPWQM states that measures to achieve policy objectives could include regulatory measures, economic instruments and communications strategies.

As is the case with other state policies, guidelines and objectives are distinguished, and the policy states that objectives are not regulatory limits. As in other jurisdictions water quality guidelines are estimates of the level of certain indicators which must be met in order to maintain an environmental value (SPWQM s. 8). Once guidelines have been set by the Board in order to determine the key indicators to achieve environmental performance, the board will use the guidelines to determine water quality objectives (SPWQM s. 9). Objectives are defined as the '...most stringent set of water quality guidelines which should be met to achieve all the protection environmental values nominated for the body of water' (SPWQM s. 9). A key feature of the policy is Division 2A under which discharges to waters are to be avoided unless it can be shown that reuse is not practical. This is discussed further in Chapter 3.

In Tasmania the 'Emission Limit Guidelines for Sewage Treatment Plants That Discharge Pollutants to Marine Waters' apply to all new and existing sewage treatment plants that report wastewater flows of between 2 and 500 kl per day and that discharge to marine or fresh water (Tasmanian Government Department of Primary Industries Water and Environment 2001). 'Accepted Modern Technology' is defined within the Tasmanian SPWQM which matches the definition contained in the '*National Water Quality Management Strategy - Policies and Principles - A reference document*' (ANZECC & ARMCANZ 1994). SPWQM guidelines include a version of the waste management hierarchy.

Problems have been identified with the implementation of the NWQMS; delays in implementing Protected Environmental Values (PEVs) for coastal areas, a lack of development of policy in line with updates and advances in National policies, and Local Governments previously using ANZECC guidelines as trigger values for water quality (Tasmanian Government Department of Environment Parks Heritage and the Arts 2008).

3.3.1.3 Microbiological recreational water quality monitoring in Tasmania

The Tasmanian Recreational Water Quality Guidelines (2007) specify procedures for managing recreational waters in the State including timing of sampling, regime for closure of waters that pose a risk to public health and sanitary inspections. The methodology followed in the guidelines involves weekly sampling at popular swimming locations. The guidelines provide two trigger values, if a sample contains a number of *enterococci* organisms higher than 140 organisms per 100ml another sample is taken within 48 hours, if the second sample is still over this limit a public warning will be required. If a single water sample contains more than 280 *enterococci* organisms per 100ml a public warning may be necessary.

Local Governments are required to monitor the quality of water within its relevant area in accordance with the aforementioned guidelines (*Public Health Act 1997* (Tas) s. 130). Further, they are required to manage waters in a manner does not pose a threat to public health, and notify the Director under Section 128 of the *Public Health Act 1997* (Tas) if this does or is likely to happen. The Tasmanian Director of Public Health produces an annual Recreational Water Annual Report based on this data (Tasmanian Government Department of Health & Human Services 2012).

3.3.2 New South Wales

3.3.2.1 Discharge licensing and environmental monitoring

The NSW Environment Protection Authority (NSW EPA) issues and regulates licences to discharge or pollute under the *Protection of the Environment Operations Act 1997* (NSW) (NSW POEO Act). Sewage treatment facilities are defined by the *POEO Act* as scheduled premises where they treat wastewater of approximately 2500 persons or equivalent or 750 kilolitres per day, whichever is greater (*POEO Act Schedule 1 s. 36)*. If a premises falls into this category it must be licenced under the NSW POEO Act. If a person wished to carry on work at a premises that is not a scheduled premises and that work would make the premises a scheduled premises, there is a requirement to obtain a licence (*POEO Act* s. 47).

The *Protection of the Environment Administration Act 1991* (NSW) Section 5 constitutes the Environment Protection Authority of NSW (‘NSW EPA’). Under Section 13A of this Act, the Minister has the power to direct the NSW EPA to refer a particular licensing matter to the Minister at which time the EPA ceases to have the power to carry out that role.

One aspect of NSW pollution licensing that differs from other jurisdictions is the introduction of load based licence fees through the *Protection of the Environment Operations (General) Regulations 2009* (NSW). The objective of this is to utilize the polluter pays principle in order that there is an incentive for industries to reduce the amount of pollutants they produce (*Protection of the Environment Operations (General) Regulations* r. 13). An environment protection licence holder is required to calculate, record and report the actual load of a pollutant (*Protection of the Environment Operations (General) Regulations* r. 15). A condition may be included in the licence which allows an agreed amount decided under a load reduction agreement to be treated as the assessable load for the purpose of deciding the fee (*Protection of the Environment Operations (General) Regulations* r. 26). The impact of load based fees in comparison to traditional licences are discussed in Chapter 4 of this thesis.

Load reduction agreements may be accompanied by a financial assurance (*Protection of the Environment Operations (General) Regulation 2009* (NSW) Div 4). Load reduction agreements may run for up to four years (*Protection of the Environment Operations (General) Regulation 2009* (NSW) r. 26). When a polluter has entered into a load reduction agreement this will reduce the licence fees they pay. However, there may be penalties for non-compliance with the agreement such as the forfeiture of any financial assurance that was required to be paid under *Protection of the Environment Operations (General) Regulation 2009* (NSW) r. 28. The agreement is given effect through a term in the operating licence for the WWTP (*Protection of the Environment Operations (General) Regulation 2009* (NSW) Section 30).

3.3.2.2 Guidelines and objectives for discharges in New South Wales

The NSW EPA is required to create environmental quality objectives, guidelines and policies and monitor the state of the environment for the purposes of achieving those objectives (*Protection of the Environment Administration Act* s. 9). Marine water quality objectives have been developed for NSW ocean waters as well as other water categories. Objectives provide the framework for applying national guidelines to local waters in NSW. As such, the objectives provide a description of the water quality which should be met in order to protect the listed environmental values. As such they are not mandatory and do not provide prescriptive indicator values (Department of Environment and Conservation (NSW) 2005). However, Chapter 5 describes how Beachwatch NSW no longer recommends the objectives for recreational water quality, instead following a modified approach based on NHMRC 2008 guidelines.

Under Chapter 2 of the POEO Act Protection of the Environment Policies (‘PEPs’) can be made. They include environment protection goals, environment protection guidelines, environment protection protocols, and environment protection standards. PEPs must be taken into consideration by local councils when undertaking certain planning actions under the *Environmental Planning and Assessment Act 1979* (NSW) s. 29. Amongst other factors the NSW EPA must consider NEPMs in preparation of Draft PEPs (*POEO Act* s. 13). It is important to note that in NSW a PEP is not a statutory rule (*POEO Act* s. 41).

3.3.2.3 Microbiological recreational water quality monitoring in New South Wales

NSW has a several microbial beach safety monitoring programs coordinated by the NSW Government Office of Environment and Heritage Beachwatch program The program expands the area it can conduct testing in by supporting local governments. These programs monitor 265 individual locations (NSW Government Department of Environment Climate Change and Water 2010). Other beach monitoring programs described in this thesis focus on capital cities in summer months, the NSW Beachwatch program includes a water quality monitoring partnership which involves some 14 NSW coastal councils.

Beach watch publishes information on monitoring and results online. This is described in Chapter 5. Further, information including the Sanitary Inspection Grade, Microbial Assessment Category, and Beach Suitability Grade for each testing location are made publically available (NSW Government Department of Environment and Heritage 2014). These monitoring programs are based upon the NHMRC 2008 guidelines (NSW Government Department of Environment Climate Change and Water 2010). As discussed above the NSW Maine Water Quality Objectives provide indicative guideline limits for recreation for example, however NSW Beachwatch relies on NHMRC 2008 guidelines.

Conditions for a polluter to monitor the receiving environment may also be included within environmental protection licences and *POEO Act* s. 64 makes it an offence to fail to comply with these conditions. Further, licence conditions may require monitoring and reporting to NSW EPA including discharges, relevant ambient conditions inside and outside the licensed premises, analysis of monitoring data and other factors as required by the Act and the licence (*POEO Act* s. 66). It is an offence to provide false and misleading information under these requirements. NSW EPA may also impose licence conditions which support pollution management including requiring the licence holder to undertake mandatory audits and environmental studies (*POEO Act* s. 67-68). An example licence condition requires the licensee to take monthly grab samples from two defined ‘ambient’ water points adjacent to the outfall to measure colony forming units of faecal coliforms per 100 millimetres (Protection of the Environment Operations Act 1997 (NSW) licence No 13972011, cl. 15).

3.3.3 Victoria

3.3.3.1 Discharge licensing and environmental monitoring

Management of pollution to waters in Victoria is principally regulated under the *Environment Protection Act 1970* (Vic) (Victorian EP Act). It is an indictable offence in Victoria to pollute waters so that the waters become noxious, poisonous, harmful or potentially harmful to health, welfare, safety or property, poisonous to life including animals, fish and vegetation, or detrimental to any environmental value (called a beneficial use in Victoria) (*Victorian EP Act 1970* s. 39(1)).

For WWTPs to discharge to waters they must hold works approvals and licences issued by EPA Victoria (*Victorian EP Act* s. 19A, 20). Wastewater treatment plants that discharge to marine or estuarine environment and exceed a design or actual flow rate of five kilolitres a day are 'Scheduled Premises' in Victoria (*Environment Protection (Scheduled Premises and Exemptions) Regulation 2007* (Vic) Schedule 1 Table 1). As a result increases or alteration wastewater discharged from WWTPs require authorization under the either a Works Approval, Licence or other approval (*Victorian EP Act* s. 19A, 20).

Notable aspects of the Victorian EP Act licensing regime include amalgamated licence which allows for the Victorian EPA to revoke licences where two or more licences apply to one premises and replace these with a single licence (*Victorian EP Act* s. 20(11A)). Licensees are also required to submit 'annual performance statements which contain information on the performance in complying with the conditions within the licence (*Victorian EP Act* s. 31D). Finally, another pollution reduction mechanism in the *Victorian EP Act* are accredited licences. These allow licence holders who can demonstrate high levels of environmental performance to apply for an accredited licence at a lower financial cost and with fewer regulatory requirements, therefore providing an economic incentive for environmental performance (*Victorian EP Act* s. 26A).

3.3.3.2 Guidelines and objectives for discharges in Victoria

State Environment Protection Policies ('SEPPs') are created under the *Victorian EP Act s. 16* and are one of five different types of policies under the Act. They differ from legislation or guidelines because they are created through an order published in the Government Gazette (*Victorian EP Act* s. 16). The objectives in the SEPPs include indicators of the environmental quality that should be reached in order to protect listed beneficial uses (environmental values). SEPPs are especially important as the guidelines. Objectives and physical parameters that they contain must be met in order to comply with the *Victorian EP Act.* Although SEPP have the effect of law, in practice some of the objectives can be aspirational in nature as opposed to being strict objectives, for example, requirements to reduce mixing zones over time (SEPP (Waters) cl. 30(2)), this is described further below.

Discharge of wastes into Victorian waters must be in accordance with the SEPP (*Victorian EP Act* s. 44). The SEPP (Waters) contains guidelines and objectives used by decision makers when creating licences, works approvals and disposal limits for the discharge of wastewater into surface waters. The SEPP (Waters) provides a list of beneficial uses for particular categories of water found in Victoria, for example, oceans and coasts. In order to protect beneficial uses in each water category the SEPP (Waters) sets objectives of environmental quality, which are found in Schedule A to the SEPP. The beneficial uses for oceans and coasts include primary and secondary contact recreation, aesthetic enjoyment, indigenous and non-indigenous cultural and spiritual values, and uses such as aquaculture, industrial, commercial use, and harvesting seafood for human consumption (SEPP (Waters) 2003 cl. 10).

The SEPP (Waters) directs that before discharges to water are allowed first the waste hierarchy should be followed. If discharges are necessary then they should not exceed the environmental quality objectives included in the SEPP and therefore should not impact beneficial uses. Where beneficial uses cannot be protected the Victorian Environment Protection Authority ('EPA') may grant a mixing zone, discussed further below (SEPP (Waters) cl 28(1)). Where discharges are allowed they should be accompanied by an Environmental Improvement Plan, and a monitoring program that ensures protection of beneficial uses (SEPP (Waters) cl 28(2)).

3.3.3.3 Microbiological recreational water quality monitoring in Victoria

Guidelines for recreational water quality management in Victoria are contained in the SEPP (Waters). These contain limits for recreational water based on a percentage of water samples taken at regular intervals over a defined period of time containing less than a prescribed value of the bacteria *E.Coli* and *enterococci*. This is not the approach taken in NHMRC 2008 guidelines. The practice of recreational water monitoring in Victoria is described fully in Chapter 5. For the purposes of this chapter it is important to highlight that the *Victorian EP Act* creates the obligation for environmental regulators to meet SEPP (Waters) in WWTP licences, not national guidelines.

The requirements for monitoring the health of Victorian waters to which wastewater has been discharged are found in individual WWTP licences. Section 38 *Victorian EP Act* requires all discharges to water to follow the SEPP (Waters). By means of example, Victorian EPA licences may require the licensee to have a monitoring program approved by the EPA (EPA Victoria Corporate Licence; East Gippsland Region Water Corporation,' (18 March 2008) Victorian Government

Environment Protection Authority 2008, cl 2B). Performance may also be reported publically through annual performance statements.

In addition to the self-monitoring process described above. EPA Victoria publishes an annual beach report for the recreational beaches of Port Phillip Bay. This report details the weekly monitoring of 36 beaches and is discussed further in Chapter 5 (EPA Victoria 2012).

3.3.4 Mixing zones

Mixing zones are pollution control regulatory mechanisms that list a distance from an effluent outfall and a range of water quality objectives that do not need to be met within that zone (ANZECC and ARMCANZ 2000a, vol. 2). This is important for this thesis because it provides an area where environmental damage may be above levels generally accepted in guidelines and policies. Mixing zones may be included in wastewater discharge licences which list a specific area in which certain criteria may not apply.

The ANZECC Guidelines define a mixing zone as '[a]n explicitly defined area around an effluent discharge where certain environmental values are not protected' (ANZECC & ARMCANZ 2000b, vol. 1, p. 2-17). The ANZECC guidelines state that mixing zones are not appropriate for substances that bio-accumulate, or for nutrients or particulate substances (ANZECC & ARMCANZ 2000b, vol. 1). The correct application of mixing zones as a pollution control mechanism is where the impact of a discharge relates primarily to concentration. An example may be the impact of freshwater on or hypersaline water on marine species.

A summary of the general guidelines for implementing a mixing zone follows (ANZECC & ARMCANZ 2000a, vol. 2):

- first follow the waste hierarchy;
- once this is done, disposal should be best practice;
- mixing zone should have a maximum size;
- the size of the mixing zone should be as small as practicable;[3]
- the size of the mixing zone should be reduced over time;
- impacts to environmental values should be limited to the mixing zone;
- impacts to environmental values should not amount to permanent degradation;
- the mixing zone should be designed to minimize ecological detriment; and

[3] Note, different jurisdictions define the mixing zone in varying manners including two and three dimensions.

- mixing zones should not be used to allow for environmental values of human health or recreation.

For example, under the Tasmanian State Policy on Water Quality Management 1997 mixing zones may be used 'if it is not reasonable or practical to reduce levels of pollution'. A mixing zone is defined as a; 'three dimensional area of the receiving waters around a point of discharge of pollutants within which it is recognised that the water quality objectives for the receiving waters may not be achieved' (Tasmanian Government 1997, pt 3.7).

In Victoria the SEPP (Waters) defines a mixing zone as;

> …an area contiguous to a licences waste discharge point and specified in that licence, where the receiving environmental quality objectives otherwise applicable under the Policy do not apply to certain indicators as specified in the licence. This means that some or all beneficial uses may not be protected in the mixing zone (SEPP (Waters) cl 3).

As an example of the application of mixing zones the SEPP (Waters) directs that mixing zones should not be approved by the Victorian EPA where they would result in risks to beneficial uses beyond the mixing zone. Mixing zones should also not be issued where the discharge results in harm to humans, unacceptable impacts on plants and animals, or causes a loss of aesthetic enjoyment or an objectionable odour (SEPP (Waters) cl. 30(1)). Where a mixing zone is applied the environment improvement plan should aim to reduce the size of the mixing zone over time, with the aim of eventually eliminating the mixing zone (SEPP (Waters) cl. 30(2)).

The Victorian EPA licence that authorised discharge from Melbourne's South East Wastewater Outfall (the case study discussed in Chapter 6), allows a mixing zone that stretches 1.7 km west, 2.3 kilometers east, and 900 meters offshore from the discharge point where there are no compliance limits for total dissolved solids. The exception for toxicant objectives is set at a 200 meters radius, and 600 meters for nutrients (Licence EM35642, Melbourne Water Corporation, Eastern Treatment Plant Bangholme 3175, Granted 15 August 1975, last updated 16 August 2005 (Victoria) 2005).

3.4 Literature Review of Barriers to Wastewater Reuse

3.4.1 Institutional and governance arrangements

Australian jurisdictions each manage urban water differently. Institutional structure and the entrenched paradigms within the water industry mean some institutions may be swayed towards large centralised schemes over decentralised infrastructure and may not be well placed to consider the benefits that wastewater reuse can provide to society, such as the amenity gained from greening urban landscapes or enhanced recreational use of surface waters formerly degraded by pollution (Stenekes et al. 2006). Byrnes et al. (2009) found greater technical efficiency in the larger utilities compared to smaller utilities they studied, hypothesising several possible causes including the attraction of key staff and the composition of boards; such that where strategic decisions are less likely to be made based on an engineering paradigm there may be a lesser tendency towards 'gold-plate infrastructure'. Byrnes et al. (2010) found efficiency was greater for similar sized regional Victorian compared to NSW utilities; of relevance to the removal of barriers to wastewater reuse was their finding that efficiency decreased when utilities had a higher proportion of industrial customers.

The Productivity Commission (2008, p. xiv) found 'monopoly provision of urban water impedes opportunities to develop alternative supply sources' and that reform had focused on governance arrangements rather than structural changes which could achieve better outcomes such as an effective market for urban water. Abbott and Cohen (2010) describe a lack of consistency within the literature with respect to optimal industry structure. As highlighted by Dollery and Crase (2010) the Productivity Commission has enhanced this area through analysis of the costs and benefits of institutional arrangements as well as establishing a suite of options for implementing reforms in both urban and regional urban water supply. The implementation of wastewater reuse and other alternative supply options has potentially been impacted by issues of the urban water sector, for example, the lost value from reduced consumption from water restrictions, inefficient and costly large scale augmentation projects, and perverse outcomes of large government grants for infrastructure (Productivity Commission 2011).

Regulatory and other impediments to reuse include cumbersome approvals processes such as absence of streamlined or integrated responsibilities for obtaining planning approval for new subdivisions with recycled water schemes (Radcliffe 2004), fixed headwork charges for developments as opposed to providing economic incentives for incorporating reuse in developments (MacDonald & Dyack 2004), lack access for investors outside of government to access wastewater and wastewater infrastructure, community and political perspectives on increasing water charges which is influenced by inadequacy of differentiation in water pricing between uses of water and the increased complexity of producing recycled water (MacDonald & Dyack 2004, Radcliffe 2004).

3.4.2 Difficulties in determining the true cost of disposal options

Inadequate recognition of the cost of externalities including environmental costs of disposal in water pricing is a barrier to wastewater reuse (Radcliffe 2004). Is has been argued that decisions on whether to invest in reuse are often based on economic market appraisals, with assessments of social and environmental factors being carried out as administrative functions in order to satisfy development or other approval processes (Listowski et al. 2009). Financial evaluations of recycled water schemes may be too simplistic and may ignore benefits of reuse, such as avoided expenditures, and ignoring non-market costs and benefits, instead focusing on capital and operational expenditure and funding (Dimitriadis 2005). Examples of non-pecuniary external costs can be seen where wastewater is disposed to surface waters. In these cases the impact of both reuse and the resultant avoided discharge are dispersed in society and are difficult, but by no means impossible, to calculate; and without their inclusions decisions on wastewater management are likely to be suboptimal (Blackwell 2008). Both pricing of externalities and quantity-based permitting are possible ways to overcome these problems however both options have their own advantages and disadvantages (Frontier Economics 2011).

3.4.3 Issues of competition and demand

In discussing demand for wastewater it seems necessary to restate the absence of an effective market for urban water, monopoly provision of urban water, and reforms focused on governance arrangements in favour of structural reforms to address this and other issues stated by the Productivity Commission (2008). What is more, structural reform will need to be implemented amongst the legacy of expense and contractual commitments to large scale desalination which in many cases were unnecessary (Productivity Commission 2011).

Factors which may increase demand for recycled water include consumer acceptance, availability of other sources of water, and increases in the price of potable water to reflect externality charges for the costs of wastewater disposal; whereas supply may be altered through advances in technology and increasing efficiency (MacDonald & Dyack 2004). Disincentives include failure to provide appropriate reduction in charges for developers using recycled water, failure to consider externalities and failure to establish an appropriate charging structure for all sources of water (Radcliffe 2004). The relative costs and complexity of recycled water when compared to other sources of water (Radcliffe 2004) are relevant to this discussion, for example, the costs of removing salinity from secondary effluent (which arises from either infiltration or industrial discharges to wastewater) (Dimitriadis 2005), and management of human behavior at the source of waste water creation (e.g. lack of price signals, volumetric charges, and external costs as indicated by Blackwell (2008)).

National recycling targets have been offered as an inadequate policy mechanism as they do not acknowledge the full costs of water nor the reality of reuse water’s price signals of competition and demand (Chanan et al. 2011). The Productivity Commission (2011) noted that removal of impediments to integration would be a better approach than assuming wastewater reuse is in the community’s interest without examining costs and benefits. Crase and O'Keefe (2012) suggest imposition of policies of water demand management in absence of price ignore the link between demand, price and supply; and selection of high-cost recycling projects in order to meet recycling targets may ignore who is impacted by the costs and may lack consideration of benefits costs analysis.

3.4.4 Inadequate water quality management

The NWC's position in its 2011 urban water paper was unequivocal in stating that regulation of water quality, and environmental and public health created barriers to integration of water management (National Water Commission 2011). Problems with water quality management are identified as a barrier to wastewater reuse (MacDonald & Dyack 2004). This includes limitations of water quality guidelines for some water uses (Radcliffe 2004). Differences have been recorded between reclaimed water guidelines and effluent discharge licences (Higgins et al. 2004). In a NWC review, Power (2010, p. xi) found inconsistent application of AGWR between Australian jurisdictions. In addition, implementation issues were identified in all Australian jurisdictions which included: '…long-term management of on-site systems, alternative disposal mechanisms, ownership of recycled water, cross-connections, decreased flow to sewers, long-term security of supplies through private service suppliers, laboratory capacities within states, and validation'.

Guidelines and discharge licences may reflect artificial separation of various stages of the water cycle; where discharge licences focus on environmental protection, recycling guidelines focus on public health and sustainability of agriculture (Higgins et al. 2004). This distinction may hinder reuse feasibility assessment by concealing the non-market benefits of wastewater reuse.

Inadequate understanding of acceptable risks amongst local regulators may lead to high monitoring costs, cumbersome approvals or isolated decision making which is focusing on one area (e.g. health or environment) and ignores broader benefits (MacDonald & Dyack 2004). The imposition of liability upon water utilities in the supply of recycled water has also been identified as a potential barrier to water recycling (Radcliffe 2004). One commentator has described precautions which were taken towards recycled water as unnecessary, for example, where the suppliers of treated water were required to continue to assist the end user in meeting their liabilities with respect to the supplied water (Jackson 2005). These issues may combine to cause wastewater reuse to appear unfavorable when compared to more traditional options.

3.4.5 Political and policy influence on decision making

Political influence may impact on the assessment of some technologies; for example, where policy bans against potable reuse of wastewater are in existence these policies are barriers to full consideration of all options and their costs and benefits (Radcliffe 2010). The Productivity

Commission (2011, p. 89) cites commentary from the National Water Commission, Australian Water Association and Business Council of Australia which ‘expressed concern that supply augmentation decisions have been made without transparent consideration of the costs and benefits of all available options’.

Khan (2011) refers to a Sydney Water comparison of desalination and indirect wastewater reuse in which augmentation of drinking water with recycled water was ruled out due to the increased costs of transferring water to a reservoir as an ‘environmental buffer’ for indirect potable reuse (IPR), whereas direct potable reuse (DPR) was not considered but would have avoided these transport costs. Advantages offered by DPR include the provision of a source of highly treated water when surface water supplies are contaminated, for example, during extreme weather events. In the State of Victoria in 2007 seawater desalination was announced without any recourse to public opinion save for the statutory rights to participate in Commonwealth environmental impact assessment after the construction of ‘preliminary works’.

Political influence may also impact the determination of how much profit should be paid by water utilities to government owners. O'Keefe et al. (2009) question the current status of many jurisdictions where profits of water utilities are diverted to government and described this as a being essentially a tax. A conflict of interest may exist where policies restraining consumption through pricing structures collide with obligations of State or local government-owned utilities to maximise returns to their shareholder; for example, where provision of recycled water would undermine objectives to increase profit from the more profitable (for example due to less complicated treatment) sale of potable water there could be conflicting objectives of profits, water pricing, provision of water and environmental objectives (Radcliffe 2004). Efficiency improvements may therefore result in higher returns to shareholders but not necessarily increased benefits to the consumer (Abbott et al. 2011).

3.4.6 Perceptions of integrated water supply options

Public acceptance and perception of risks from wastewater are well documented barriers to wastewater reuse (Jefferson et al. 2000, MacDonald & Dyack 2004, Radcliffe 2004, Dolnicar et al. 2010). However, public input is somewhat limited by not being able to participate in a functioning urban water market (as described in Section 1.4.1) and an inability for the public to openly view information on the non-pecuniary impacts of various options, for example, openly accessing information on the environmental impacts of wastewater disposal.

Willingness to pay for recycled water has also emerged as an area of study however there is little discourse on drivers for wastewater disposal; which is the primary alternative to wastewater reuse. The ability for the public to make informed decisions about the impacts of wastewater discharges is limited by their access to information which, in many cases, is collected and held by government or water authorities. Further, the impacts of wastewater discharge are often underwater and out of the public eye, and water quality monitoring in many areas assesses long term trends (focusing on median and 90th percentiles of samples taken weekly or monthly) while individual high risk days may go unreported. These factors may hinder the public's ability to comprehend the impacts of wastewater disposal and therefore hinders their ability to make informed decisions on their willingness to pay for recycled water.

Stenekes et al. (2006, p. 128) describe public acceptance of water recycling as a 'minefield of assumption and rhetoric [and] is widely used as a way to explain the lack of progress on water recycling'. They argue that this may conceal other influences on decision making such as institutional conservatism and other factors. Research on the public and recycling may also have a narrow focus on public preferences and attitudes as of end-users as a prediction of future behavior without developing an understanding of the factors which precede the frameworks and approaches under which institutions resolve issues (Mooney and Stenekes 2008).

The perceptions of decision makers and water industry employees may influence the selection of integrated water management options and the options that are considered for selection. A qualitative study which examined the experience of managers of 12 representative Australian recycled water schemes identified environmental abatement as the primary factor influencing the initial decision to invest in the scheme (Muston & Wille 2006). A survey of water practitioners in Brisbane, Melbourne and Perth showed receptivity for uses of sewage was high for industrial and public open space, but low or average for drinking, indoor and outdoor household use and environmental flows, further, while the practitioners perceived "environmental outcomes" as a driver to on-site reuse schemes and third-pipe schemes, no perceived driver was identified for potable reuse (Brown et al. 2009). Martin (2006) found that surveyed 'stakeholders' perceived the greatest barrier as financial and economic impediments including financial costs of recycled water infrastructure as well as cost relative to other sources of water.

While it is accepted that perceptions may be dynamic and rapidly changing, at the very least it may be argued that the evidence presented above indicates that perceptions of water practitioners did not align with the stated position of the NWC (2010) towards open minded and transparent consideration of all options towards integrated water cycle management.

3.5 Conclusion

This chapter provides an overview of the legal regime for monitoring and maintaining water quality in Australia, as well as describing wastewater disposal regulation in Victoria, New South

Wales and Tasmania. The NWQMS provides guidance for state and local regulators and managers which allows for development of parameters and standards for waters to which wastewater is disposed as well as recreational waters. The NWQMS guidelines which apply to recreational water are the NHMRC 2008 recreational guidelines. Legislation managing wastewater discharges to water is set by State governments such as environment protection legislation and water quality guidelines. Notable features of wastewater regulation include Tasmanian SPWQM which requires discharges to be avoided unless it can be shown that reuse is not practical (discussed in Chapter 3) and load based licensing in New South Wales (discussed in Chapter 4). Further details on the on the ground practice and application are provided in subsequent chapters. Notably, Victoria, NSW and Tasmanian recreational water quality ‘guidelines’ all use different methods to determine the microbiological water quality of recreational water, the subject of Chapters 5, 6 and 7.

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PART 2 – BARRIERS TO ASSESSING THE FEASIBILITY OF WASTEWATER REUSE

Details of publication of Chapter 3 - Wastewater reuse in the absence of water scarcity and a market: A case study from Beaconsfield, Tasmania (Australia)

This chapter was presented as a peer reviewed conference paper at the 2013 Asia Pacific Water Recycling Conference & Membranes and Desalination Conference. Sections have been edited in order to accommodate inclusion in a thesis as well as providing additional information in Section 3.8. Details of authors and their contribution can be found in the opening pages of this thesis.

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4 Wastewater reuse in the absence of water scarcity and a market: A case study from Beaconsfield, Tasmania (Australia)

4.1 Abstract

This chapter describes the formation of the urban water industry in Tasmania. The recent commencement of a wastewater reuse scheme to irrigate a tree-lot in Beaconsfield (Tasmania) may represent a prescient view of the future of wastewater reuse in Tasmania. The case study in this chapter is returned to in Chapter 4 where environmental regulation and process is discussed. This chapter provides a background to the historical and current issues with urban water management in Tasmania which have led to current environmental problems. This chapter canvases specific Tasmanian governance and policy drivers and barriers to this and other wastewater reuse schemes, whereas Chapter 4 focuses on the reuse assessment itself in order to discuss barriers to reuse which may be applied more broadly across Australia. The chapter finds that governance structures and past underinvestment present challenges to a hastened search for a balance between providing a return on assets and rapidly achieving the goal of sustainable water management. The understanding of these challenges is critical for decision makers when assessing the costs and benefits of upgrading assets and reforming the industry.

4.2 Introduction

In 2008 the State Government of Tasmania passed legislation to remove urban water management from 29 local governments and form the Tasmanian water and sewerage industry. ‘Sustained under investment’ resulted in low compliance of wastewater discharges and pollution of Tasmanian waters (Office of the Tasmanian Economic Regulator 2011, p. iv). Local government management was even described as a ‘litany of mismanagement’ (Property Council of Australia 2012, p. 5); approximately $1 billion of capital investment was required before Tasmania’s water infrastructure could reach levels of compliance present in other Australian jurisdictions ("Water and Sewerage Industry Bill 2008 Second Reading Speech" 2008).

Of central concern to this chapter and the reform agenda for Tasmania are the conflicting demands of wastewater management in Tasmania. Foisted returns for local government and corporatized wastewater assets can adversely impact available funding for capital improvement. This has the imminence to denigrate the rate at which compliance is improved and thus the volume of reused wastewater (Office of the Tasmanian Economic Regulator 2012b).

In order to draw-out the salient features of these conflicting demands we use the example of a scheme announced as a ‘pilot or demonstration’ project for reuse in Tasmania (Wightman 2012). The case study involves a tree-lot irrigation scheme at Beaconsfield wastewater treatment plant (WWTP) and is supplemented with evidence from submissions, inquiries and information collection was supported through interviews.

Within this ‘reuse’ describes wastewater disposed through reuse schemes described by Tasmanian regulators as reuse schemes, under which definition they include land application of wastewater. This chapter refers to the regional water corporation ‘Ben Lomond Water Corporation’ which has since been replaced with the state wide TasWater. The assessment referred to in this chapter and Chapter 4 were carried out by Ben Lomond Water prior to the creation of TasWater.

The remainder of this chapter is set-out in five sections. The first section provides an overview of the evolution of Tasmanian urban water management from 2006 to 2013. Section 2 discusses the current malaise of wastewater reuse in Tasmania. Section 3 discusses elements of Tasmanian urban water governance and microeconomic reform which may be barriers to wastewater reuse. Section 4 presents a case study and finally, Section 5 provides a discussion. The chapter concludes with some brief closing remarks.

4.3 Tasmanian urban water management from 2006-2014

In 2006 a Tasmanian Government Ministerial water and sewage taskforce was formed in response to underperforming water and sewage infrastructure (Government of Tasmania 2006). The Tasmanian State Government passed legislation in 2008 which brought about structural reform of the water and sewage industry and in 2009 three local government owned regional urban water and sewage corporations were formed under the *Water and Sewerage Industry Act 2008* (Tas) and the *Water and Sewerage Corporations Act 2008* (Tas), as well as an additional corporation to provide services to the three regional corporations. On 1 July 2013 Tasmania’s water and sewerage corporations were merged into a single utility called TasWater.

The 2006 Tasmanian Government Ministerial Water and Sewerage Taskforce discussion paper stated; ‘there is growing evidence that Tasmania’s water and sewerage infrastructure has not kept pace with the State’s strong economic progress in recent years’ (Government of Tasmania 2006, p.3). This included ‘widespread non-compliance of sewerage treatment plants with their environmental permits’ (Office of the Tasmanian Economic Regulator 2012b, p. ix). Regulatory non-compliance of Tasmanian WWTPs required ‘significant capital expenditure to overcome the environmental damage caused by ageing wastewater treatment plants’ (Ben Lomond Water 2012b, p. 44).

Wastewater which escapes reuse is discharged to estuarine environments, to a lesser extent to marine waters, and finally, inland waters. In the 2011-2012 reporting period 49 out of 78 Level 2 WWTPs were less than 90 percent compliant with discharge to waters limits; and 24 of 78 Level 2 WWTPs were operating over maximum licence flow limits by more than 100 percent, indicating demand for wastewater treatment outmatches supply in these regions (Office of the Tasmanian Economic Regulator 2013).

In response to these shortcomings, three regional urban water and sewerage corporations and a shared ‘common service provider’ were formed under the *Water and Sewerage Corporations Act 2008* (Tas). In June 2013 these corporations were merged to form a single statewide corporation under the *Water and Sewerage Corporations Act 2012* (Tas).

The move to a single corporation in Tasmania was enacted through State Government legislation and followed a vote of a special meeting of the Local Government Association of Tasmania (LGAT) (Local Government Association Tasmania 2012). The LGAT had been critical of the initial State government taskforce as ‘relying upon a submission process and a series of informal discussions with council representatives’ (LGAT 2007 p3).

Tasmania’s local governments own the urban water infrastructure as well as the water and sewerage corporation and receive returns in the form of dividends, tax equivalents and guarantee funds. Local governments retain responsibility for the management of stormwater as well as recreational water quality monitoring. Local governments oversee the management of the corporation through a shareholders letter of expectation (Tasmanian Water and Sewerage Corporation (Northern Region) 2009). Tasmanian Water and Sewerage Corporation (Northern Region), Ben Lomond Water, Launceston, as well as an ‘Owner’s Representative Group’ which makes decisions on board remuneration and dividends. The Tasmanian Government retains a role through the regulators and has provided price caps and customer reimbursements (House of Assembly Select Committee into Tasmanian Water and Sewerage Corporations 2012).

The *Water and Sewerage Industry Act 2008* (Tas) establishes the structure of the industry including price regulation as well as the powers and reporting requirements of the economic regulator. The economic regulator of the industry is the Office of the Tasmanian Economic Regulator. The economic reforms were altered in 2010 when the Tasmanian Government placed an interim price cap restricting charge increases to five percent and providing water users with a share of an $8.9 million dollar rebate package (Bartlett 2009).

The environmental regulator is the Board of the Environment Protection Authority (‘Tasmanian EPA’) and the Director of Public Health (Department of Health and Human Services (DHHS)), exercises responsibilities under the *Public Health Act 1997* (Tas) (Office of the Tasmanian Economic Regulator 2013).

Table 3.1 displays the key benefits of the reform as stated on its introduction; these benefits are further separated into three categories.

Table 3.1: Stated benefits of Tasmanian water and sewerage reform ("Water and Sewerage Industry Bill 2008 Second Reading Speech" 2008).

Benefit	Key element
Accountability of services	Operating licence regime
	Independent regulation of prices
	Enhanced public performance requirements
Efficiency and performance	Enhanced asset management planning
	Removing duplicated activities of exiting regulators
Customer service	Minimum customer service standards
	Established ombudsman for customer complaints

4.4 Wastewater reuse in Tasmania

In 2013 the Tasmanian Economic Regulator reported that in the previous reporting period 6.5 percent of urban wastewater produced in Tasmania was recycled. This included five full reuse schemes, 28 partial reuse schemes (however, 15 of the partial reuse schemes reused less than 50 percent of total wastewater) and 46 WWTPs providing no reuse. Wastewater which is reused is primarily treated to Class B standard[4] and applied to land for irrigation of golf courses, farms, tree lots, bush blocks and similar land based disposal methods (Office of the Tasmanian Economic Regulator 2013).

Known issues with the State's WWTPs and reuse schemes include; public risk from environmental discharges and wastewater reuse, uncertainty and risk including unsatisfactory contractual arrangements for wastewater reuse involving third parties, and inability to utilize wet periods due to lack of storage and lack of demand for irrigation during these periods (Ben Lomond Water 2011b).

Ben Lomond Water described the wastewater reuse schemes under its management;

> These re-use schemes do not generate a profit as there is little or no market for the re-used water and it is delivered to the recipient free of charge or for a nominal amount. The primary purpose for these re-use schemes is land disposal of treated effluent.
>
> Accordingly, the re-use schemes are fundamentally "disposal" schemes and the revenues, expenses and assets are all part of the delivery of regulated sewerage services (Ben Lomond Water 2012b, p. 32).

[4] Class B is a standard established in the '*Tasmanian Recycled Water Guidelines*' Environment Protection Authority (Tasmania). 2001. Environmental Guidelines for the Use of Recycled Water in Tasmania. Department of Primary Industries Water and Environment, Hobart, December 2002.

This statement refers to thirteen effluent reuse schemes established by councils in the State's North East, instigated by Commonwealth funding, generally on private land, some of which included level of contribution from the landholder, for which only four generate a volumetric charge or annual fee (Ben Lomond Water 2012b).

Table 3.2 shows that total compliance with existing permit conditions is lower when compared to 'Accepted Modern Technology'[5] (AMT) limits. When AMT is considered, the flow weighted compliance of effluent discharged to water lowered by 22 percent (Ben Lomond Water) 27 percent (Southern Water) and 23.6 percent (Cradle Mountain Water) (Office of the Tasmanian Economic Regulator 2013). A range of factors account for differences in reuse percentage between authorities including, population and rainfall patterns.

Table 3.2: Compliance with discharge to waters' and reuse limits 2011-2012 (Office of the Tasmanian Economic Regulator 2013 pp. 110-114).

	Compliant effluent (%)	AMT compliance (%)	Effluent reuse (%)[6]
Ben Lomond Water	92	70	5
Southern Water	89	62	11
Cradle Mountain Water	84.6	61	<2

The Economic Regulator noted that the level of regulatory compliance of Tasmania's WWTPs may be a poor representation of environmental sustainability due to the gap between existing permit conditions and AMT, as well as differences between treatment licenses and assessment methodologies (Office of the Tasmanian Economic Regulator, 2013).

4.5 The Tasmanian EPA and wastewater reuse feasibility assessments

The Tasmanian EPA has commenced updating Tasmania's Environment Protection Notices ('EPNs') for WWTPs.[7] Rather than reflecting the assimilative capacity of the receiving environment, the EPNs, issued in 2011-2012, reflect the capacity of existing facilities under optimized operations. These interim limits would be expected to be eventually replaced with conditions that meet AMT (Office of the Tasmanian Economic Regulator, 2013).

Tasmania's State Policy on Water Quality Management 1997, Section 15.1 requires the Tasmanian EPA to only issue an EPN to authorize a discharge to waters once satisfied that either reuse/recycling or discharge to land are not practical. Utilising the necessary process of updating EPNs, the EPA

[5] Accepted Modern Technology is defined in the State Policy on Water Quality Management 1997 (Tasmania) Section 4.1.
[6] These values were approximated from the report.
[7] 'Level 2' WWTPs require an EPN to be issued by the environmental regulator under *Environmental Management and Pollution Control Act 1994 (Tas)*.

decided that where there is an environmental discharge and where reuse had not ‘previously been satisfactorily explored’ a condition would be introduced into the EPN to require the permit holder to conduct a feasibility study for effluent reuse (EPA Tasmania 2011b). An allocation of $2.8 million was assigned to the process of updating the water and recycled water quality policies over a three year period (EPA Tasmania 2011a).

In 2011 the Tasmanian EPA released the ‘Effluent Reuse Feasibility Study Guidelines’. The guidelines establish a broad process for assessing the feasibility of reuse for a WWTP. The guidelines leave the specific methodology within the phases of the assessment open. However other jurisdictions may have no such guidelines and wastewater reuse feasibility assessments may be performed on an as need basis, as described in Chapter 4. The procedures contained within these guidelines to be followed to assess wastewater reuse feasibility are discussed further in Chapter 4.

The process envisioned by the Effluent Reuse Feasibility Study Guidelines (2011b) is to first, scope and identify potential options for effluent reuse at the WWTP. An overview must be presented of the site-specific factors such as water quality, land uses and availability and relevant maps, any potential issues caused by trade waste or the effluent, and general restrictions of the area which may limit reuse. The Guidelines go on to state that initial options identification should be followed by consultation. Depending on the options chosen through the scoping process, the consultation could potentially be broad and involve advertising, public meetings and interviews. This is followed by the scoping of options, a process of information gathering to investigate the options. Finally, a report should be prepared which includes scoped costing estimates for the options and a rationale to support decisions in the form of a triple bottom line assessment (EPA Tasmania 2011b).

4.6 Factors impacting the volume of wastewater reuse in Tasmania

Table 3.3 (below) divides some of the barriers to wastewater reuse in Tasmania into categories of physical barriers and financial and economic barriers.

From 2009-2013 the water corporation’s primary focus was provision of potable water ahead of upgrading wastewater infrastructure which resulted in limited WWTP upgrades with the focus instead on optimization and lower cost improvements (Office of the Tasmanian Economic Regulator 2013).

One key barrier is the drain that required dividends have on much needed capital for infrastructure upgrades. Another four barriers to the delivery of objectives were proposed in a submission on behalf of the Tasmanian Water and Sewerage Corporations: 1) involvement of the Tasmanian government in capping previously agreed to price increases prior to the 2010 election; 2) financial and economic constraints including ‘…a fear that political pressure could undermine the independent economic regulation of the sector…' (Onstream 2010, p. 4); 3) structural tensions including managing the expectations of returns by council owners created by the corporate model; and 4) pressure placed on capital funding by the need to service previously un-serviced populations (Onstream 2010).

Table 3.3: Factors impacting the volume of wastewater reuse in Tasmania (Onstream 2010) (Office of the Tasmanian Economic Regulator 2013).

	Barrier to reuse
Physical	Climate, availability of water and lack of demand
	Absence of land in proximity to WWTPs for land based discharge
	Inadequate storage and/or demand during wet periods
Financial and economic	Absence of capital for investment and requirement to pay dividends
	Government intervention reducing revenue base (interim price cap)
	Potential for political pressure to undermine independent economic regulation
	Structural tensions including expectations for returns exacerbated by corporate governance model
	Need to provide services in previously unserviced areas
	Prioritised investment for critical projects including provision of adequate drinking water

4.7 Financial and economic barriers to reuse

4.7.1 Is the rate of return on water and sewerage assets appropriate?

There is evidence that the requirement to pay dividends to local government is a barrier to capital expenditure:

> The EPA noted that the limit of available funds for capital expenditure is an obstacle to improved compliance and this obstacle is exacerbated by dividend payments to local government owners before the regulated entities are operating on a sustainable footing (where sustainability also includes meeting regulatory obligations) (Office of the Tasmanian Economic Regulator 2012b, p. 44).

The dividend policy for Ben Lomond Water required a dividend distribution target of 50 percent of after tax profit which is paid in addition to the payment of income tax equivalents and payments from guarantee bonds (Tasmanian Water and Sewerage Corporation (Northern Region) 2009).

The financial position of Ben Lomond Water and Cradle Mountain Water were expected to become financially unsustainable (Office of the Tasmanian Economic Regulator 2012b). It has been argued that this creates an inconsistency under the *Water and Sewerage Corporations Act 2008* (Tas) which requires the dividend policy to be both consistent with good commercial practice and to make adequate provision for future capital investment and operational expenses *before* a dividend is paid (Property Council of Australia, 2012).

The House of Assembly Select Committee into the Tasmanian Water and Sewerage Corporations quote Miles Hampton in their 2012 report when recounting his meetings with various councils;

> They wanted to see us increasing the dividends. Their language would be they wanted there to be no price increases; I interpreted that to mean that they wanted price increases to be kept as low as possible, because the former is unrealistic whereas the latter is realistic (House of Assembly Select Committee into the Tasmanian Water and Sewerage Corporations 2012, p. 16).

Payment of income tax equivalents and guarantee funds in addition to dividend payments were justified based on the COAG obligations of competitive neutrality (Council of Australian Governments (COAG) 2006) for businesses in the public sector ("Water and Sewerage Corporation Bill 2012 Second Reading Speech" 2012). It is difficult to comprehend the necessity for competitive neutrality in circumstances where a single water and sewerage corporation exists without competition and where to do so denies revenue to investment which is required to remedy risks to public health and safety and the environment.

There is also evidence in the case of one corporation that the amount of profits that some local governments would retain following the reforms were inflated by shifting the balance of fees collected away from water and towards the general rate, thereby increasing the amount of revenue the councils' retained through general rates and decreasing the starting revenue of the water corporations (Parliament of Tasmania House of Assembly Select Committee on Water and Sewerage 2011).

4.7.2 Are structural tensions and past management practices barriers to improved environmental compliance?

While many existing reuse schemes were initiated through Commonwealth funding, the current ability to access to similar funding was commented upon by one State Government representative;

> The State Government is correctly of the view that they don't own the water and sewerage problem anymore. If you are leaning on them they will apply on your behalf, but they do not have any single drive on their own to represent your best interests at Federal Government level (Parliament of Tasmania House of Assembly Select Committee on Water and Sewerage 2011, p. 2).

A 2010 LGAT press release entitled "Hands Off Water and Sewerage" reveals structural tensions that existed throughout the reform stating '[I]f the State Government thinks that it can just march in and covet billions of dollars worth of ratepayer assets, then it had better think again' (LGAT 2010). The LGAT press release goes on to provide an insight into the tension between State and local government which surrounded the negotiations leading up to the 2008 reforms stating '[W]e worked with the State Government to try to get an outcome that was workable. There was a lot they didn't like about the process and a whole lot more that we didn't like, particularly the haste with which it was done' (LGAT 2010).

In 2007 the LGAT represented that the process of the Tasmanian Government Ministerial Water and Sewerage Taskforce (2006) should consider historic investment by local government and that local governments were '…best placed to deliver water and sewerage services around the state…' (LGAT 2007, p. 10). In 2004-2005 for wastewater 11 municipalities returned a rate greater than 4 percent, 13 returned less than 4 per cent and 3 reported a negative rate of return (Government of Tasmania 2006).

The statement below suggests that the LGAT believed that there was a disincentive to initiating investment in water and wastewater infrastructure because to do so would result in the application of national standards to a WWTP's discharge;

> The application of a national standard to a new facility generally means that the discharge conditions are far more onerous than those applied to the facilities of immediate council neighbours. This creates a disincentive (sic) toward upgrade as any improvement process is likely to trigger additional conditions that are unaffordable and arguably, unnecessary. The issue should relate to the impact on receiving waters (LGAT 2007, p. 7).

However the Office of the Tasmanian Economic Regulator's 2012 *Water and Sewerage Price Determination Investigation Final Report* notes the Tasmanian EPA's assessment that its compliance expectations for the corporations were much higher than the expectations it placed on councils (Office of the Tasmanian Economic Regulator 2012b). The application of stricter standards following a period of underinvestment may be responsible for a bottleneck of required capital investment.

4.8 Case study

A number of the salient barriers to wastewater reuse are exemplified in the case study of Beaconsfield WWTP. By way of introduction, the plant was constructed in 1980 with a capacity of 400KL a day to service a population of approximately 400 people (Ben Lomond Water 2011b). The facility had been identified by the Tasmanian EPA of one of several WWTPs which was a high priority for upgrade as it was not complying with environmental licence conditions for wastewater discharge. The solution that was chosen for this site was the construction of a 49 hectare tree-lot irrigation reuse scheme.

The Compliance Implementation Plan for the Tasmanian Water and Sewerage Corporation (Northern Region) Pty Ltd directed EPA Tasmania to develop a priority framework for WWTP upgrades. The

2009 EPA Tasmania 'Priority Framework for Level 2 WWTPs' listed 10 WWTPs as high priority, 9 WWTPs as medium priority and 9 WWTPs as low priority. Beaconsfield WWTP was the second highest priority on the list, which was agreed to by Ben Lomond Water and the Tasmanian EPA (Ben Lomond Water 2011b). Problems at Beaconsfield WWTP included lack of flow monitoring, and inlet screening. Implementation of these items commenced prior to the larger task of effluent reuse (Ben Lomond Water 2011b).

The Minister for Environment and Heritage announced that the scheme 'may prove to be a pilot or demonstration project for other sewage treatment plants in this and other regions of the State' (Wightman, 2012). Ben Lomond Water announced the Beaconsfield wastewater reuse scheme as an economical way to reduce nutrients to surface waters as well as avoiding costly upgrades (Ben Lomond Water 2012a).

Under the *Water and Sewerage Industry Act 2008* (Tas) licence issued to Ben Lomond Water it was required to submit a WWMP to Tasmanian EPA. The WWMP was created to assist the organisation and regulators to assess how to prioritise investments on WWTPs. The WWMP is described as a 'flexible and living document' because it describes Ben Lomond Water's wastewater infrastructure assets, plans, and the requirements of relevant regulators (Ben Lomond Water 2011b). Capital expenditure on this process was also influenced by other improvement priorities regulated by State Government departments including the DHHS and the Office of the Tasmanian Economic Regulator (Ben Lomond Water 2011b).

Reuse feasibility assessment commenced after the Ben Lomond Water Wastewater Management Plan was agreed to between Ben Lomond Water and the Tasmanian EPA; it identified the WWTP as a high priority due to its impact on receiving waters (Ben Lomond Water 2011b). This was followed by an investigation of the costs of a range of options showing full reuse as the lowest cost option (GHD 2011). Following this technical investigations were undertaken and a Development Proposal and Environment Management Plan (DP & EMP) (Ben Lomond Water 2011a). The DP & EMP is also assessed by the local council for its planning aspects. Requirements for the contents of a DP & EMP for WWTPs are contained in guidelines prepared by the Tasmanian EPA (Environment Protection Authority (Tasmania) 2012).The process of this feasibility assessment and the outcomes are described further in Chapter 4. In addition, a stated benefit of this option was that in owning the reuse scheme removes risks associated with providing wastewater to third parties (GHD, 2011). Ben Lomond Water's existing schemes were located on private land and the Price and Service Plan documents the risk in relation to the schemes; it refers to the contracts for the schemes which were signed before Ben Lomond Water existed (Ben Lomond Water 2012b).

Before reuse wastewater was discharged to a tributary of the Tamar estuary which often had no natural flow, thus required ratios of 80 parts river water to 1 part wastewater were not achieved (GHD 2011). Without full wastewater reuse environmental discharge would continue and this imposed costs including upgrading the treatment plant and potentially constructing a new outfall into the larger body of water (GHD 2011). Table 3.4 compares the indicators which are listed in the EPN for both discharge to water and discharge to reuse scheme.

Table 3.4: EPN limits for effluent discharged to water and discharge to a reuse scheme (Environment Protection Notice No. 7934/3)

Indicator	Reuse	Discharge
pH	6.0 - 9.0	6.5 - 8.5
Thermotolerant coliforms (cfu/100ml)	<10,000 (Median)	500 (Max)
Biochemical Oxygen Demand (mg/L)	80 (Max)	30 (Max)

Table 3.5 shows the three parameters from the licence for Beaconsfield WWTP in place from 1992-2011 (Licence No.3597, 1992), and compares these to the same parameters in the 2011 EPN (Environment Protection Notice 7934/1, 2011, EF6-1). The limit on several parameters was raised in the second licence, and there was an increase in compliance for two parameters.

Table 3.5: Discharge compliance limits for Beaconsfield WWTP (Ben Lomond Water, 2011b)[a]

Parameter	Limit (Maximum) 1992/2011	Percentage Compliance 2010/2011
Biochemical Oxygen Demand (5 day) mg/L)	20 / 30	43% / 100%
Non-filterable Residue / Suspended Solids (mg/L)	30 / 50	43% / 60%
Thermotolerant Coliforms (cfu/100 ml)[b]	200 / 500	43% / 0%

Notes; a. Other parameters included in the 2011 EPN have been excluded as these did not contain numerical limits in the 1992 EPN. b. CFU – Colony forming units

4.9 Discussion

In the case study of this chapter, sustainable wastewater reuse in the form of tree lot irrigation or other similar schemes was argued to be an economical way to reduce discharge of nutrients to surface waters. On the other hand, using land based disposal as a means of regulatory avoidance creates a new set of risks to manage by shifting the environmental, social or economic impacts in time and space; for example, by shifting impacts from surface water to groundwater (Mitchell 2006).

Tasmanian water quality policies require reuse to be considered before disposal (State Policy on Water Quality Management 1997). The absence of a direct reuse market may not equate with a lack of demand, for example, where wastewater is discharged to a river system and accessed for use downstream for other purposes. However, the blanket application of reuse targets may result in inequities due to local variables (Crase & O'Keefe 2012).

The case study identified ‘risks’ associated with supply of recycled water to third parties as a factor in decision making. Requirements for the supplier of recycled water to manage risks associated with the use of recycled water which has been supplied to a third party can be unnecessary or unreasonable (Jackson 2005). Conversely, there may be circumstances where wastewater reuse would not be possible without the supplier providing ongoing expertise and retaining risk. If the Tasmanian governance structure necessitates avoiding such risk this may create barriers to reuse.

The appropriateness of diversion of a portion of water bills into another arm of government as a ‘de facto tax’ has been questioned (O'Keefe et al. 2009). It is also counterintuitive that infrastructure could return a positive rate of return while at the same time not meet regulatory requirements. Wastewater infrastructure has been linked to gastrointestinal human health sickness in over 100 people through consumption of contaminated commercially farmed shellfish (ABC News 2013). The question of whether a water bill is the appropriate mechanism for local government to collect revenue to be used in areas other than urban water and sewerage should therefore be a test of public interest which asks: What more urgent spending priorities justify diverting funds, where to do so would slow the rate of public health related infrastructure upgrades?

The Productivity Commission has affirmed the importance of independence of utilities and regulators from government decision making on matters of public interest, and that the primary objective of the urban water sector is the provision of services in an economically efficient manner on behalf of the community (Productivity Commission 2011). The requirement for urban water to provide a commercial return on assets, places the water and sewerage corporation in a contradictory position between political and community resistance towards increasing charges, and the need to provide sanitation. This may be magnified by past ‘under investment’ (Office of the Economic Regulator 2012).

It is hoped that the merger of the Tasmanian water corporations will increase the efficiency of delivery of water and sewerage services. There is evidence that points towards relative efficiencies through similar larger board driven organisations when compared to local government (Byrnes et al. 2010); conversely, there may be disadvantages of local government amalgamation and policy objectives may be better achieved through shared service provision (Dollery, Byrnes & Crase, 2007). In either event, it is suggested that strategic priority documents which decide the timing of investment were in place before the 2012 reform and this would be expected to limit the impact of the reform on the timing of improvements to wastewater infrastructure.

If the principle of competitive neutrality is applied without simultaneously ensuring other aspects of competition reform are present, such as the possibility for private competitors to enter the market, the policy merely serves to direct more revenue away from water and sewerage. When considering microeconomic and other water governance reform it is important that the Productivity Commission's primary objectives are not forgotten, that is, that citizens gain improved services in a more efficient manner. If this is not achieved the reform has failed.

4.10 Conclusion

The decision to reform Tasmania's malaised urban water and sewerage sector has allowed regulators to provide input into the strategic priorities and investments for the industry. In the immediate future, while parts of the drinking water supply as well as many effluent discharges to waters remain non-compliant, it is likely that reuse of urban wastewater in Tasmania will not be dealt with as a stand-alone priority. While requirements to generate profits may push the outcomes of cost benefit analysis away from options for which the main benefits are non-pecuniary, the ruminating message from the Beaconsfield case study is that not being able to provide solutions that generate income based on the volume of wastewater sold should not justify doing nothing at all. The barriers to wastewater reuse, as identified in this chapter, are critical to the analysis of necessary future reform of the industry. Avaricious policies, such as requiring a dividend payment, instead of investment in much needed infrastructure to meet public health obligations, should be immediately apparent to the decision makers and citizens as unethical and indefensible.

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5 Systemic barriers to wastewater reuse in Australia: Some jurisdictional examples

5.1 Abstract

This Chapter describes the regulatory framework and assessment process of urban wastewater reuse in two distinct regions of Australia, the Tamar Valley in northern Tasmania and the Hunter region of New South Wales. Relative similarities are evident between human population, water availability and recent necessity for reuse feasibility assessments. In the Hunter region, assessments informed a State government led catchment scale water security strategy. In Launceston, the need for assessments stems from a condition of the environmental permits for individual facilities. Salient institutional, social, economic, and political barriers mire the assessment process for, and success of, wastewater reuse. Distinct legal, policy and procedural differences exist between the two cases. Future reuse guidelines should identify the different drivers for wastewater reuse and avoid studies that only serve to meet administratively predetermined selections.

5.2 Introduction

The first condition of the National Water Commission's (NWC's) position on urban water reuse is that cost-benefit and risk analyses should be undertaken to 'take full account of social and environmental externalities and avoided costs' (NWC 2010, p.1). Assessment of costs and benefits prior to commencing wastewater reuse is an important step to ensure water management is sustainable and avoid a mere corporate promotional display. This chapter contributes to our understanding of the factors that influence the inter-jurisdictional inconsistency of such assessments and reuse determination by describing the requirements and processes of two urban water and sewage institutions: the former Ben Lomond Water Corporation (Ben Lomond Water), which until recently existed in the north-east of Tasmania; and the Hunter Water Corporation (Hunter Water) in eastern New South Wales (NSW) (Figure 4.1).

One barrier to reuse is that much of Australia's wastewater infrastructure has been built as part of a one directional, non-integrated supply network (NWC 2007). In part, the reason for these inadequate networks lies in an inattention to the social dimensions of water (Harriden & Graymore 2013) resulting in ineffective collaborative management (Lukasiewicz et al. 2013). Under these networks, wastewater and stormwater are collected, treated, and then discharged to the environment, 'with insufficient regard to the impacts on the receiving environment' (NWC 2007, p. 7). Additionally, due to the historical and continued disregard for these 'external' impacts for groups in society, the rising demand for water is met with increased supply and discharged wastewater (NWC 2007), perniciously imposing further impacts on receiving environments. While Marsden Jacob Associates (2013) consider these impacts to be relatively small or rarely occurring, Blackwell and Willcox (2009) estimate the lost benefits for recreational users of a single beach of tens of millions of dollars annually. By reducing these adverse impacts, wastewater reuse offers an alternative to discharge, which can assist in meeting the goals of integrated water cycle and collaborative management.

As the case studies show, recycling schemes vary by application, scale, and the roles of parties, required levels of treatment, ability to fund capital and operational investment, and whether they are operated on a ‘not for profit’, or on a commercial basis. These variations result in contrasting outcomes for the assessment and success of reuse. For example, Melbourne's Eastern Treatment Plant discharges large volumes of Class A quality wastewater without reuse because several large scale reuse options did not meet cost-benefit balance requirements set by the Victorian State Government’s business case (Melbourne Water 2009). Inconsistently, the business as usual option, disposal of wastewater, required no such business case.

5.3 Feasibility assessment of wastewater reuse in Australia

Feasibility studies for the implementation of integrated water cycle management options assess potential impacts of a proposal in order to allow a decision to be made on whether to invest in it (Urkiaga et al. 2008). Options for supply from traditional water sources are compared with options for wastewater recycling by contrasting the cost of producing recycled water with estimated market demand or willingness to pay (Hurlimann 2009). However, decisions to increase recycling equate to decisions to decrease discharge. Given a business case for discharge is not required, as in the Melbourne’s Eastern Treatment Plant example (Melbourne Water 2009), the external benefits of decreased discharge, such as improvements to water quality and beach recreational activities (Blackwell & Willcox 2009), are not factored into reuse assessments.

Whether a proposed reuse technology is economically feasible involves consideration of technical, geographical, social and economic factors (Urkiaga et al. 2008). These factors will almost certainly vary between jurisdictions and sites. The NWC (2010, p. 1) position in favour of urban water recycling is ‘subject to four conditions’ including that ‘prior cost/benefit and risk analyses are conducted which take full account of social and environmental externalities and avoided costs…’, best available science and regulatory arrangements (based on the Australian Guidelines for Water Recycling (AGWR) (Natural Resource Management Ministerial Council et al. 2006)), and finally community participation in decisions to implement recycling schemes which have transparent and accountable management arrangements.

AGWR address risk management (Environment Protection and Heritage Council 2008). That said, there are *no* national guidelines for assessing costs and benefits of wastewater reuse. The process of developing such guidelines would draw on existing guidelines from other jurisdictions (Urkiaga et al. 2006), and methodologies for assessing the performance of reuse projects (Urkiaga et al. 2008), and for determining and calculating internal costs, externalities and opportunity costs (Hernandez et al. 2006).

5.4 Systemic Barriers to Assessing Wastewater Reuse

5.4.1 Summary of systemic barriers to reuse and commentary

The broad literature on barriers to reuse (presented in Chapter 2) is summarised in Table 4.1 and grouped into six main types, with details of how each aspect could impact the assessment or success of wastewater reuse. Barriers that have economic ramifications include: institutional and governance arrangements (Table 4.1, item 1), difficulties in determining the true cost of disposal options (item 2), and those that relate to demand and competition (item 3). The remaining three types: inadequate water quality management (item 4), political and policy influence on decision making (item 5), and perceptions of integrated water supply options (item 6), combine with the first three to sufficiently obscure or ‘muddy the waters’ for the transparent and complete assessment or success of reuse. This chapter refers to this ‘muddying of the waters’ as ‘coalescing concealment’, which results in a heightened likelihood of failure for wastewater reuse projects. Four examples help to clarify the workings of the concept with reference to the six main types of barriers (Table 4.1).

The first example of coalescing concealment is that institutional and governance issues (Table 4.1, item 1), such as monopoly service provision and no competitive market for urban water (Productivity Commission 2011), manifest as economic problems in determining the true cost of disposal (item 2) and demand (item 3) for reuse (Stenekes et al. 2006). With an ineffective wastewater market where there are no price and volumetric charges as a mechanism to connect supply with demand decisions (Blackwell & Iacovino 2009), or no externality pricing (Radcliffe 2004), or no complete cost-benefit analyses that account for the external effects of water use and wastewater disposal (Blackwell & Willcox, 2009), wastewater reuse projects are preconditioned to fail (Dimitriadis 2005). Without volumetric charges, there is no incentive to reduce at its source (e.g. at point of use of the toilet) the creation of wastewater, in turn resulting in lower reuse demand (Blackwell & Iacovino 2009). Without the inclusion of the external benefits of increased water recycling, such as through improved recreational benefits from better ocean and beach water quality, cost-benefit analyses of water recycling and reuse are incomplete and biased (Blackwell & Willcox 2009). There are such a large number of problems associated with the institutional framework (item 1) and economics (items 2 and 3) of wastewater reuse and recycling that these projects are more likely to fail (Blackwell & Iacovino 2009).

A second example of coalescing concealment with institutional and governance arrangements is a focus on end user perceptions (Table 4.1, item 6) rather than the framework and processes (items 1 and 5) through which these perceptions perpetuate, which can also lead to premature failure (Mooney & Stenekes 2008). Several potable reuse projects have failed because of public opinion, impacted by communication, transparency and perceived fairness; in particular the loss of trust (Hurlimann and McKay 2004). It is often argued that a 'social contract' has been created to not proceed with drinking recycled water (McKay 2007). Toowoomba experienced a rushed public information campaign, politics and manipulation of information (Hurlimann & Dolnicar 2010). This may be better reframed as a barrier created by the behavior of public institutions (items 1 and 5) resulting in mistrust (item 6).

Table 4.1. Systemic barriers to wastewater reuse

Barrier type	Aspect	Detail where applicable
1. Institutional and governance arrangements	Jurisdictional differences in managing urban water	Entrenched paradigms; large centralised schemes result (Stenekes et al. 2006)
	Institutions not well placed to consider broader benefits	(e.g. greening landscapes, surface water recreation (Stenekes et al. 2006))
	Greater technical efficiency in larger regional utilities (Byrnes et al. 2010)	Greater economic efficiency with smaller utilities and fewer industrial customers.
		Less infrastructure 'gold plating' where strategic decisions rely less on engineering paradigm
	Industry structure suboptimal	No effective market for urban water (Abbott & Cohen 2010)
		Lost value from water restriction reduced consumption (Productivity Commission 2011)
		Inefficient, costly large scale augmentation projects (Productivity Commission 2011)
		Large government infrastructure grants' perverse incentives (Productivity Commission 2011)
	Cumbersome approval processes	Subdivisions with recycled water schemes (Radcliffe 2004)
	Increased complexity of producing recycled water (Radcliffe 2004)	
	Development fixed headwork charges discourage reuse (MacDonald & Dyack 2004)	
	Non-government investor poor infrastructure access (MacDonald & Dyack 2004)	

Barrier type	Aspect	Detail where applicable
	Poor water pricing differentiation based on use (MacDonald & Dyack 2004);	
2. Difficulties in determining the true cost of disposal options	Inadequate recognition of externalities in water pricing (Radcliffe 2004)	Includes inadequate recognition of disposal externalities, which have been quantified (Blackwell & Willcox 2009)
	Investment decisions based on market appraisals	Lack proper consideration of social and environmental impacts (Listowski et al. 2009)
	Financial evaluations too simplistic	Ignore externalities, focus on capital and operational expenditure (Dimitriadis 2005)
	Wastewater management decisions are therefore likely to be suboptimal (Blackwell & Iacovino 2009)	No externality pricing and quotas provide second best solutions (Frontier Economics 2011)
	Decision maker inadequate understanding of risks	Impede reuse and create unnecessary monitoring costs and lengthened approvals (MacDonald & Dyack 2004)
	Outfalls provide ability to continue to dispose of toxic waste at sea (Beder 1992)	Avoid costly upgrade required for land treatment (Beder 1992)
3. Issues of competition and demand	Demand: No effective market for urban water (Productivity Commission 2011)	Increases may result from consumer acceptance, availability of alternative sources, increases in potable water price to reflect disposal externalities (Blackwell & Iacovino 2009)
	Supply: urban water monopoly provision (Productivity Commission 2011); governance versus structural reform focus (Productivity Commission 2011); desalination cost legacy (Productivity Commission 2011)	Increases may result from technological advances and efficiency gains (MacDonald & Dyack 2004) Decreases from failure to provide subsidy for developments with recycled water schemes, failure to include externalities in water prices, & appropriate price structures for all water sources (Radcliffe 2004). For example: • salinity removal costs for secondary effluent from industrial discharge (Dimitriadis 2005); • managing human behaviour at the source of wastewater creation because of lack of price signals and volumetric charges (Blackwell & Iacovino 2009)
	Recycling targets inadequate	Do not include full costs of water or price signals reflecting competition, demand (Chanan et al. 2011) or supply

Barrier type	Aspect	Detail where applicable
		Ignores who is impacted and use of benefit-cost analysis (Crase & O'Keefe 2012)
	Removing impediments to integrated water systems (Productivity Commission 2011)	
4. Inadequate water quality management	Not cost-effective and creates barriers to integrated water management (NWC 2011)	Inconsistent application of AGWR across jurisdictions (Power 2010)
		Liability onus on water utility (Radcliffe 2004)
	Juxtaposition of guidelines (pub. health, agriculture sustainability) & discharge licenses (environmental protection) (Higgins et al. 2004) conceal broader benefits	Reclaimed water different to effluent discharge guidelines (Higgins et al. 2004)
	Local regulator inadequate understanding of acceptable risks (MacDonald & Dyack 2004)	High monitoring costs
		Cumbersome approvals
		Isolated decision making
5. Political and policy influence on decision making	Prohibition of potable reuse (Radcliffe 2010)	
	Transparent consideration of costs, benefits not undertaken (Productivity Commission 2011)	(e.g., Wonthaggi Desalination, Sydney Water (Khan 2011))
	Shareholding Minister's Conflict of interest (Radcliffe 2004)	Dividend trade off against broader beneficiaries (Abbott et al. 2011)
		Dividend simply a tax (O'Keefe et al. 2009)
6. Perceptions of integrated water supply options	Public acceptance and perception of risks (Dolnicar et al.2010; Jefferson et al. 2000; Radcliffe 2004)	Little discourse on social and political drivers *vis-a-vis* scientific or engineering drivers (e.g., Ludwig & Storrs 1970; Thompson et al. 1992))
	While willingness to pay quantification emerging (Jiménez-Cisneros & Ahuja 2014; Menegaki et al.; Tziakis et al. 2009)	Assumption and rhetoric may conceal institutional conservatism (Stenekes et al. 2006)
		End-user preference focus prevents understanding of preceding institutional frameworks/approaches determining preferences (Mooney & Stenekes 2008)
	While perceptions of reuse improving (Dolnicar & Schäfer 2009), informed WTP decisions hindered by:	• public input limited by inability to participate in an urban water market (Blackwell & Iacovino 2009)
		• information asymmetry on environmental impacts of government/water authorities'

Barrier type	Aspect	Detail where applicable
		controlled disposal (Blackwell & Iacovino 2009)
		• underwater wastewater discharge away from public eye; non-existent timely accurate high risk day reporting (Blackwell & Iacovino 2009)
	Decision maker and water industry perceptions	Environmental abatement important (Muston & Wille 2006)
	Brisbane, Melbourne, Perth (Brown et al. 2009)	Receptivity high for industrial and public open space
		Receptivity low/average for drinking, indoor/outdoor household use, and environmental flows
		Environmental outcomes drive onsite reuse and third pipe schemes
		No perceived driver for potable reuse
	Greatest impediment is financial cost relative to other sources (Martin 2006)	

A third example, inadequate understanding of risks by decision makers (Table 4.1, item 2), may be an impediment to wastewater reuse and may lead to unnecessary monitoring costs or lengthened approvals (MacDonald & Dyack, 2004). There is also a risk that when one discharge ceases, the environmental, social and economic burdens of one practice are shifted (item 3) to another location, water system, or to a future date (Mitchell, 2006). This could occur where a land or water discharge is justified on the grounds that this option will delay necessary upgrades to underperforming infrastructure. For example, Beder (1992) describes the decision to extend ocean outfalls in Sydney under the motivation of avoiding the costs and inhibitory land requirements of secondary treatment, as well as the added benefit of being able to allow industry to continue to dispose of toxic waste to sewers.

The fourth example is where political and policy influence (Table 4.1, item 5) remove the need for transparent and objective cost-benefit assessments of alternative infrastructure to that of wastewater reuse (Khan 2011; Productivity Commission 2011). A related fifth example involves inadequate management of water quality (Table 4.1, item 4), driven by political concern (item 5) and conflicts of interest for shareholding ministers (Abbott et al. 2011; Radcliffe 2004) rather than equitable or efficient treatment.

5.5 The Case Studies

5.5.1 Ben Lomond Water, Tasmania

5.5.1.1 Background

Recent concerns with the performance of Ben Lomond Water's WWTPs (Figure 4.1) included elevated levels of bacteria, nutrients and organic matter discharge into rivers and coastal waters, and low discharge compliance compared with water authorities in other Australian jurisdictions (Office of the Tasmanian Economic Regulator 2012). To assist assessment of how to prioritise investments on WWTPs, Ben Lomond Water was required, under its license, to submit a Wastewater Management Plan (WWMP) to EPA Tasmania (*Water and Sewerage Industry Act 2008* (Tas)). This process identified discharges creating public risk, poor plant performance, contaminated biosolids, lack of trade waste agreements with some industries, lack of flow monitoring, bypass of peak flows direct to receiving waters, population growth, and peak inflows exceeding EPA limits, reuse schemes without formal reuse agreements in place, third party controlled irrigation, mismatch of irrigation demand with effluent volumes, and irrigation areas and reuse storages too small for full reuse (Ben Lomond Water 2011c).

5.5.1.2 Tasmanian Effluent Reuse Feasibility Study Guidelines

In 2009, EPA Tasmania began to introduce a new regulatory framework for wastewater treatment and disposal (Environment Protection Authority (Tasmania) 2011a). One aspect of the new framework involves including a condition within some WWTPs Environment Protection Notices (EPNs) that an effluent re-use feasibility study be completed. Environment Protection Authority Tasmania Effluent Reuse Feasibility Study Guidelines (2011b) lay out broad issues to include in the study including option costing estimates and a triple bottom line assessment and public consultation. The outcome of this process is either a written undertaking towards full reuse, or an Emission Limit Guidelines Compliance Plan and a Discharge Management Plan (Environment Protection Authority (Tasmania) 2011b).

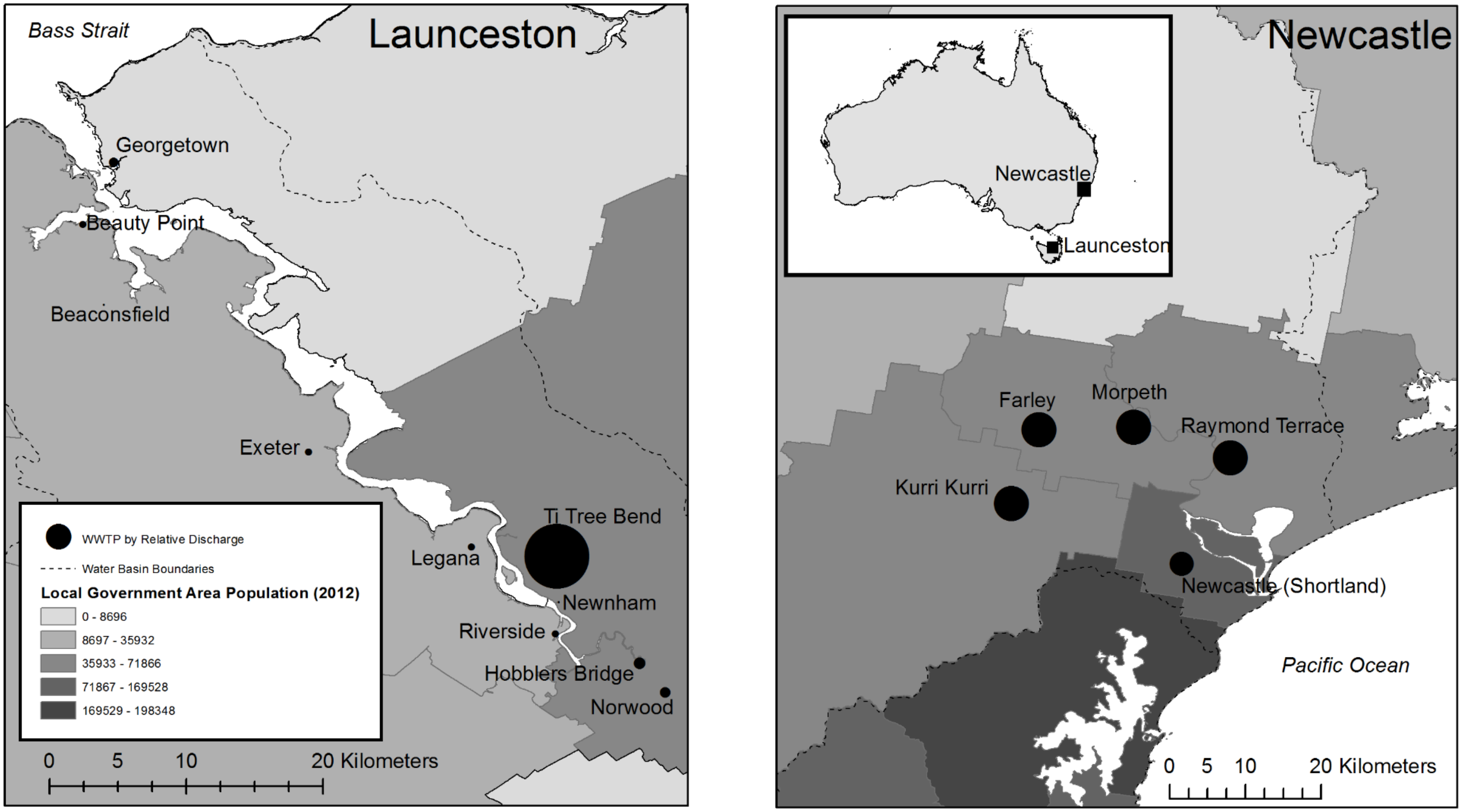

Figure 4.1. Ben Lomond Water (Launceston) and Hunter Water (Newcastle) Waste Water Treatment Plants (WWTPs), comparable relative discharge and LGA populations. Sources: Water basins, www.geoscience.gov.au; Local Government Area Population 2012, www.abs.gov.au; Discharge, Ben Lomond Water (2011c, pp. 63-171) and Environment Protection Authority (NSW) (2012).

5.5.1.3 Environmental and planning approvals process

Figure 4.2 summarises the process of obtaining an approval for the Beaconsfield wastewater reuse scheme (Figure 4.1 indicates the location and relatively small discharge of Beaconsfield WWTP). WWTP regulation and assessment is split between several State government departments and local government. Local Government has regulatory responsibility for wastewater reuse schemes as well as planning approvals under the *Land Use Planning and Approvals Act 1993* (Tas). EPA Tasmania has responsibility for establishing limits for discharge to water in the Environment Protection Notice (EPN) under the *Environmental Management and Pollution Control Act 1994* (Tas) (EMPC Act). However environmental impact assessment is carried out by an informal grouping of staff from various State Government departments called the Wastewater Reuse Coordinating Group (WRCG) (Environment Division (DPIWE), 2002). The WRCG has no legislative basis, but has extensive responsibilities: evaluating the Development Proposal and Environment Management Plan (DP & EMP); forming management conditions; endorsing the EPN; and, future review of the scheme 'from time to time' (Ben Lomond Water 2011b).

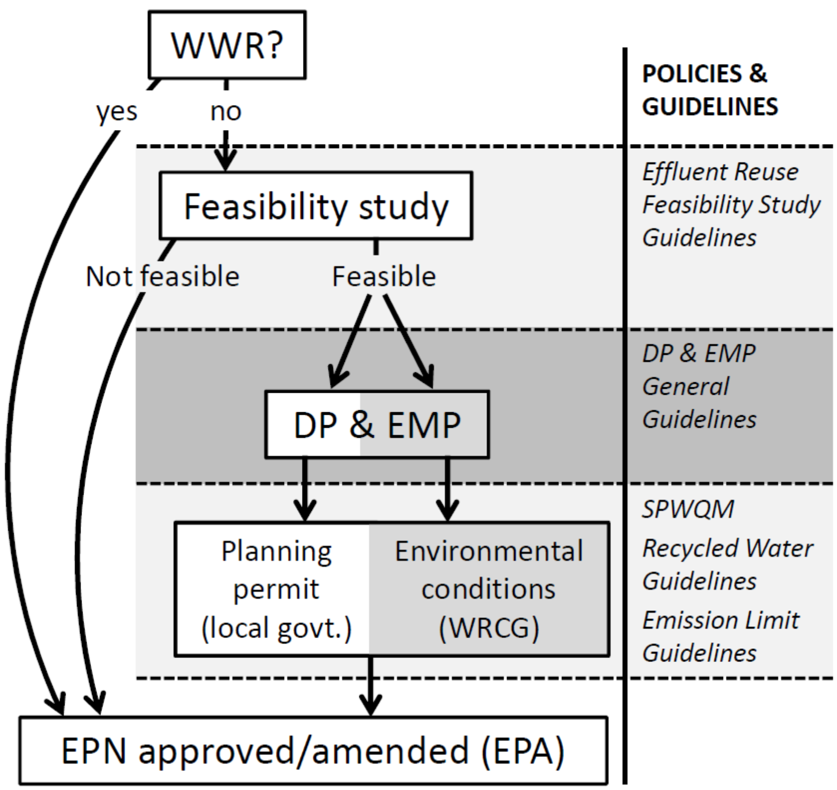

Figure 4.2: Process of Wastewater Reuse Feasibility Study, Development Proposal and Environment Management Plan (DP&EMP), and amendment/approval of Environment Protection Notice (EPN) for Tasmanian WWTPs over 100kl/day hydraulic loading, which have no wastewater

reuse (WWR). Includes assessment of environmental sustainability by Wastewater Reuse Coordinating Group (WRCG) applying Environmental Guidelines for the use of Recycled Water in Tasmania, State Policy on Water Quality Management 1997 (SPWQM) and Emission Limit Guidelines. Sources: Ben Lomond Water 2011c; Environment Protection Authority (Tasmania) 2009; Power 2010.

5.5.1.4 Wastewater reuse feasibility assessment at Beaconsfield WWTP

In summary, the process involved an options analysis assessing costs, risks, advantages and disadvantages of various options (GHD 2011). This was followed by exploration of the technical aspects such as soil environmental suitablity in the process of preparing the DP & EMP. In 1995, the treatment plant had previously been assessed as being unsuitable for reuse. Factors mentioned within the DP & EMP that changed the feasibility of reuse include WWTP performance, available land adjacent to the site. Motivations for reuse included reduced discharge, visual and environmental benefits of planting trees, removal of discharge, and potential benefits of preservation of remnant local flora and provision of habitat to some species of fauna (Ben Lomond Water 2011b). Acquiring land also reduced risks and administrative complexity of dealing with third parties. The option of full-reuse on land owned by the authority was the lowest capital expenditure option ($2,359,000), followed by discharge to water with no reuse ($4,240,000), and finally partial reuse and discharge to water ($5,330,000) (GHD 2011, p. 45). The increased cost for both options involving discharge to water reflects the costs of upgrading the treatment process and constructing infrastructure including an effluent outfall. Upon completion of this process, the option of a tree lot irrigation scheme and associated storage dam in Beaconsfield was selected at a cost of approximately AU$2.5 million (Ben Lomond Water 2012).

5.6 Hunter Water Corporation, NSW

5.6.1 Background

Hunter Water is responsible under the *Hunter Water Act 1991 (NSW)* for catchment management, urban water supply and sanitation in the Hunter Region of NSW (Figure 4.1). Hunter Water developed the Hunter River Catchment Effluent Management Master Plan (the Master Plan) (Figure 4.3), which formed a step in the compilation of the Lower Hunter Water Plan that covers drought security in the area and is led by the NSW Metropolitan Water Directorate (2014) (Hunter Water 2011). The Master Plan includes an analysis of wastewater management scenarios for reuse for a 30 year period and relates to five WWTPs within the region. Only one WWTP was exceeding Load Based Licence (LBL) limits at the time of the study; however, two were expected to exceed their LBL limits in the future (Sinclair Knight Merz 2012).

The Lower Hunter Water Plan was led by the Metropolitan Water Directorate, a division of the NSW Department of Finance and Services. Supply of recycled water falls under Hunter Water's operating licence which is monitored by the Independent Pricing and Regulatory Tribunal (IPART). Whereas environmental licensing for WWTPs falls under the *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) and the Environment Protection Authority (EPA).

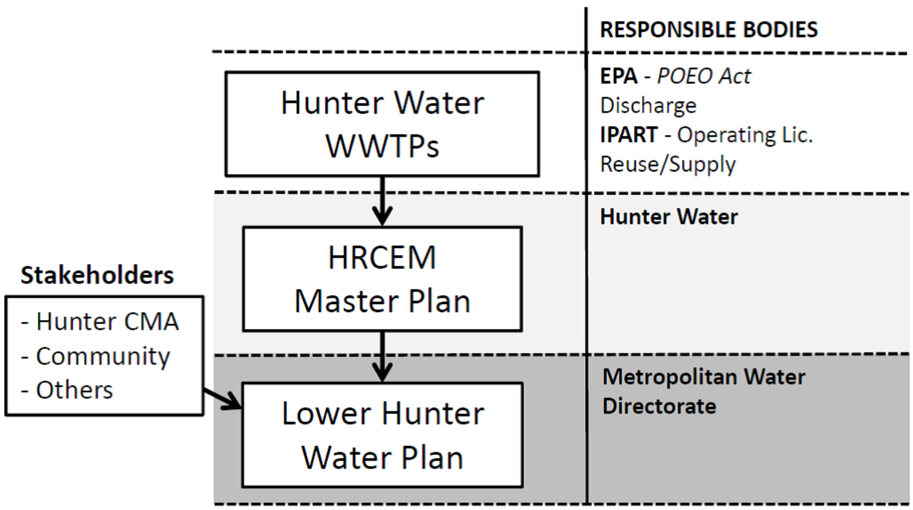

Figure 4.3: Flow chart, Hunter River Catchment Effluent Management Master Plan (HRCEM Master Plan) progression into the Lower Hunter Water Plan. Hunter-Central Rivers Catchment Management Authority (Hunter CMA) and other stakeholders provide input. Hunter Water WWTPs are regulated by the EPA (NSW) by licences issued under the Protection of the Environment Operations Act 1997 (NSW) (POEO Act) and the Independent Pricing and Regulatory Tribunal (IPART). Source: Hunter Water 2011; Power 2010; SKM 2012.

5.6.2 Load based licences (LBL)

In NSW, when a polluter seeks to upgrade a WWTP and reduce the load of pollutants, the polluter may enter a load reduction agreement for up to four years; this may be accompanied by a claimable EPA financial assurance in the event that the agreed load is not met (*Protection of the Environment Operations (General) Regulation 2009* (NSW), s. 30 & Div. 4). These agreements reduce the fees payable under a LBL and therefore tend to provide incentives to upgrade WWTPs. (Figure 4.3). For example, the Newcastle Sewerage System (Burwood Beach WWTP and ocean discharge) paid an administrative fee of

$46,460, a total pollutant fee of $339,238.90, and a load based fee of $295,138.90 for the 2009-2010 financial year (Environment Protection Authority (NSW) 2012).

5.6.3 Wastewater reuse feasibility assessment for the Master Plan

The wastewater management options analysis was carried out by Sinclair Knight Merz (SKM). Each option delivered different social, environmental and economic costs and benefits. The options canvassed included: (1) continuing to treat and release, (2) transferring from non-compliant WWTPs to other plants, (3) transferring wastewater to ocean outfall, (3) non-potable reuse to a point that complies with licence conditions, (4) non-potable reuse for all new developments, (5) local agricultural reuse, (6) a private irrigation scheme, and (7) three options involving potable reuse (SKM 2012). There are existing recycled water schemes in this region.

These options were compared using multi-criteria analysis (SKM 2012). This style of analysis allowed the investigator to develop each option to a point where enough was known to generate a score for each option based on criteria developed under the categories of social, environmental and technical factors. Criteria were broadly grouped into social, environmental and technical, with sub-criteria of ‘community acceptance’, ‘expected water quality impacts’ and ‘chemical use’ (SKM 2012, p. 51). A workshop of stakeholders assessed the options and a financial analysis was undertaken for each option. The final report found the options producing the lowest cost per kilolitre of water were also the two highest ranked scenarios when all the factors were considered. The rankings were: (1) treat and release, $1.56/kl, (2) reuse in a private irrigated wine district, $3.10/kl, (3) direct potable recycling, $4.19/kl, and (4) indirect potable recycling, $4.36/kl (SKM 2012, p. 3). While treat and release and agricultural reuse were estimated to save 4,052ML of potable water a year, the two lower cost potable options were estimated to save 20,855ML of potable water a year (SKM 2012, p. 3).

5.7 Discussion – Impacts on Assessment Process

5.7.1 Governance structures

The NSW assessment process consolidated different effluent management options into scenarios or combinations of options to be presented to a State Government department to assist in forming long-term management objectives for the entire catchment. By contrast, the Tasmanian effluent reuse feasibility assessment was required under the WWTPs environmental permit and the WWTP upgrade framework, which was determined by EPA Tasmania in consultation with the water corporation. Differences are evident between the disciplinary expertise of the staff of the departments who ultimately guide strategic decision making in NSW and those of the Tasmanian WRCG who assess the sustainability of wastewater reuse at different facilities. A catchment scale plan could be carried out in Tasmania; however, the Tasmanian Water and Sewage Corporation is not responsible for catchments, drainage and stormwater; except to the extent of their responsibility to manage urban water and sewage.

Having a centralised government department coordinate assessment of wastewater reuse feasibility assessments of single WWTPs into regional strategies may have advantages. For example, they could identify opportunities across a broader area and ensure that the views of different stakeholders are considered (e.g., options are fully considered and initial selection is not overly influenced by one set of drivers, such as political influence). Another potential benefit is the identification of the potential for bubble licences that allow organisations that hold multiple licences to group discharges in an area for the purpose of determining total loads. Local assessments may have advantages over larger regional assessments for their ability to identify local knowledge in a cost effective manner and to avoid putting offside communities located closest to the new assets.

While in both the Tasmanian and NSW cases the process leaned towards low cost, low technology options, such assessments can overlook the external benefits of alternative options. For example, in some circumstances higher cost, more complex options may result in reduced external costs, such as improvements in receiving water quality, improved recreational opportunities and treatment upgrade or infrastructure transfer avoidance. A fundamental criticism of least cost approaches is that they do not necessarily provide the optimal or greatest net benefit test from cost-benefit analysis (Tietenberg 1992). Given that multi-criteria analysis was used to assess and rank the options in the NSW case, rather than a thorough assessment of all benefits through a social cost-benefit analysis, it is expected that reuse options that provide greater volumes of potable water at a higher cost would be ranked lower.

With respect to governance structures, the Tasmanian water and sewerage reforms relied on the formation of new institutions and governance arrangements for wastewater management. This has the potential to shift the political focus of decisions away from State and Local Governments onto the new water industry. Perraton et al. (2013) argue that the current requirements for the pursuit of profits, at the expense of public health outcomes in Tasmania, are not necessarily in the best interest of the public. A point of interest for future research is whether the merger of Tasmanian water corporations into one state-wide water corporation results in moves towards regional assessment of wastewater reuse feasibility as described in the NSW case study.

5.7.2 Environmental regulation– Load based licensing (LBL)

As evidenced by the NSW case study, LBL may allow societal costs of pollution to be internalised in exchange for the incentive of reduced fees for improved environmental performance. Command and control pollution regulation is criticised for not producing results, being cumbersome to enforce, and not providing incentives for pollution reduction below set limits (Bernstein 1993). LBL offers an alternative to command and control pollution regulation (Raha 2007) because it charges the cumulative impacts of the load on the receiving environment, and it provides flexibility for the licensee and regulator to agree on the compliance method. Thus, it is designed to provide economic incentives and utilise markets to promote pollution reduction (Environment Protection Authority (NSW) 1998).

LBL can be compared to Tasmanian permits which contain maximum parameter and concentration limits. Traditional concentration based licences charge either a set fee, or a fee based on the scale or class of an activity. Providing an economic incentive to maintain water quality should impact cost-benefit analysis in favour of options that reduce the discharge of certain pollutants. However achieving this may not always result in wastewater reuse (Institute for Sustainable Futures 2013).

In Tasmania, environmental conditions for wastewater discharge are expected to be made more stringent following a period of ‘prolonged underinvestment’ (Office of the Tasmanian Economic Regulator 2011, p. iv). Therefore, all things being equal, a resulting decrease in compliance is expected (Office of the Tasmanian Economic Regulator 2012). However, in the Tasmanian Beaconsfield case, compliance actually increased for some indicators prior to the upgrade following the issuance of lower standards in the new permit, as shown by tracking compliance (Ben Lomond Water 2011a) against limits set in 1992 and 2011 (Beaconsfield WWTP, Licence No.3597; Licence No.3597, 1992).

In NSW, drastic increases in fees for pollutant loads were not likely to become an immediate concern, partly due to previous wastewater infrastructure investment planning. By comparison, in Tasmania, many WWTPs in the region were already exceeding discharge limits. It is possible that in Tasmania the total amount of capital expenditure required to upgrade a large portion of existing water and wastewater infrastructure, as well as the greater urgency of other upgrades (e.g., drinking water), may impact spending priorities, favouring lower cost reuse options.

5.7.3 Environmental regulation– Transparency and regulatory uncertainty

The drivers for each of the reuse case studies in this chapter were primarily environment protection in Tasmania and water planning in NSW. However, the same environment protection policies existed in

Tasmania before and after reform; yet the commitment to and ability of the regulator to enforce environmental policies impacting the uptake of wastewater reuse has changed.

Tasmania's State water quality policy (SPWQM) and environmental legislation (EMPC Act) remained the same before and after water industry reforms. Much of the language within the SPWQM is aspirational and, for WWTPs, enforceable limits and details for water quality are in WWTP licences. The environmental regulators appear to have used the creation of a water corporation and removal of urban water and sewage management from councils to trigger the re-issuing of many outdated licences. If water governance structures are reformed but environmental regulations are not, it is open to the same problems that led to licences requiring re-issuing at a future date. This finding is significant because it has implications beyond Tasmania where other Australian states, such as Victoria, have similar problems with regulatory uncertainty for environment protection in water (Roberts and Craig 2014).

The process described in this chapter adds to findings that LBL tends only to drive reduced discharge and not reuse (Institute for Sustainable Futures 2013), by highlighting the potential for a shift in research focus on the barriers to wastewater recycling to include policy factors which make disposal more advantageous than reuse. This could occur where an environmental regulator has sufficient power to push the aspirational aspects of policies. This is illustrated by the NSW Department of Environment and Heritage (2014) Beachwatch program, which provides public feedback on recreational water quality, and is far more extensive than Tasmania's monitoring arrangements. Significantly, this disparity is repeated in all Australian jurisdictions and means different populations have different access to information on disposal impacts which could impact willingness to pay for recycled water.

Lack of procedural transparency or uncertainty within the assessment process, or in areas of water quality management, are potentially barriers to wastewater reuse. For example, if the regulator's expectations are unknown at the outset, or there are procedural intricacies that may only be obvious to people within the process, the associated uncertainty may discourage investment. The (1) reliance on aspirational non-binding mechanisms for environmental protection, when combined with (2) a lack of incentives for meeting these, (3) a lack of procedural transparency such as in the establishment of licences that protect water quality in receiving waters, and (4) the level of government at which wastewater recycling is planned, combine as barriers to wastewater reuse. Behind these combining barriers is the coalescing concealment of the potential benefits from wastewater reuse.

From an economic perspective, the most important reform for transparent assessment of wastewater reuse proposals would be consistent and dependable cost-benefit assessment guidelines. Because these are non-existent for Australia, the lack of guidelines has the potential to provide for considerable regulatory uncertainty, especially for those in greatest need of the guidelines; that is, those who bear the costs of a poorly performing industry, the general population.

5.8 Conclusion

When recycling projects are considered, it is important to question their benefits in the contexts of water quality improvement, economic burden and impacts on the community. Decisions on infrastructure can have ongoing implications for many decades after the initial investment. Therefore, it is crucial that feasibility assessments stem from and inform strategic direction both regionally and nationally.

The two case studies presented provide examples of the different institutional frameworks under which investment decisions may be framed. In both cases, leadership from State government departments was a driver for the assessment of wastewater reuse. Centralised leadership, as documented in the NSW case study, may be a mechanism to ensure that wastewater reuse feasibility assessment is carried out in a consistent manner and as part of the creation of long-term strategies informed by all stakeholders. In Tasmania, the driver for the urgency of water quality improvements may be favouring the assessment of smaller areas. Feasibility of wastewater reuse was influenced by many factors, including the costs of continued environmental discharge. The variation in the case studies indicates that the success of any future Australian guidelines for wastewater reuse assessment may be determined by their ability to accommodate the different drivers for wastewater reuse without allowing studies to become merely administrative requirements where the preferred option is already selected.

5.9 References

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PART 3 – MANAGEMENT OF WASTEWATER DISPOSAL IMPACTS: RECREATIONAL WATER QUALITY

Details of publication of Chapter 5, Chapter 6 and Chapter 7

It is intended to submit an edited version of Chapter 5 for publication with the Australasian Journal of Environmental Management. It is intended to submit Chapter 6 to the Journal of Coastal Management. It is intended to submit Chapter 7 to the Journal of Local Environment.

6 Extreme variation in Australian recreational water quality management guidelines and practice: overcoming legal and policy challenges

6.1 Abstract

Recreational water quality management in Australia was reviewed revealing inconsistencies in communication of risk and microbiological limits both within and between jurisdictions. When combined with lack of clarity on communication of risks and short term water quality limits in national guidelines the result is that each state has developed its own approach to manage water-borne illness that may result from wastewater disposal. Some jurisdictions use traffic light (red, amber, green) communication systems to represent compliance with national guidelines but NSW and Victorian Beach watch programs also use these to represent daily microbiological water quality, whereas Northern Territory uses it to indicate weekly monitoring results. All states except South Australia have developed limits for when a single sample shows high numbers of Faecal Indicator Bacteria (FIB) however this is not included in national guidelines. South Australia and NSW and Victorian Beach watch programs have developed daily warnings based on predictions of FIB, however other states simply advise swimmers to avoid swimming for between 24 hours and 5 days following rain. Reforms, which may help overcome barriers to consistency among reporting methods include; 1) communication and innovations states have adopted on their own accord, 2) national research forums for the validation and verification of limits and methods, 3) better support for local governments to enable consistent statewide implementation, and 4) linking federal government grants to reporting results in a nationally consistent format.

6.2 Introduction

This chapter describes the malaise induced by non-binding guidelines, policies and informal management practices taken by Australian jurisdictions to implement National Medical Research Council Guidelines for Managing Risks in Recreational Water 2008 (NHMRC 2008) guidelines, the chapter suggests a path forward to overcome the legal and constitutional impediments to a uniform national approach. Australia's Constitution does not give the Commonwealth government power to make laws over water or water quality and as a result, each state and territory sets its own water quality laws and policies. The federal government has developed a National Water Quality Management Strategy (NWQMS) and the NHMRC 2008 guidelines are one document of the NWQMS. The guidelines are not mandatory but instead aim to provide guidance for development of local guidelines and practices to support a 'nationally harmonised approach' (NHMRC 2008, p11).

In some regions state government departments or state funded programs perform the physical act of monitoring microbiological water quality. In most other areas, recreational water monitoring is carried out by local government officers. NHMRC 2008 guidelines follow the approach laid out in World Health Organisation 2003 Guidelines for Safe Recreational Water Environments (World Health Organization 2003) and contain non-binding international standards for assessing the risk of marine pollution to the health of recreational water users. NHMRC (2008) guidelines apply the WHO (2003) guidelines in an Australian context and include non-binding national guidelines for the monitoring of bacterial water pollution and recreational safety. The process of using the NHMRC 2008 guidelines to assess health risks and their development is described elsewhere (Hickey & Cowie 2003, Abbott et al. 2011).

NHMRC 2008 guidelines also cover risk factors other than microbiological indicators, such as cyanobacteria and physical and chemical hazards. Monitoring and communication of microbiological water quality of recreational waters has important implications for public health. NHMRC 2008 describe the risks of contracting recreational water illness from contact with recreational waters polluted by microbiological pollution from faecal sources. These illnesses include enteric illness (self-limiting gastroenteritis), respiratory, eye, or skin infections, and in some circumstances, liver or renal disease or central nervous system illness.

New South Wales (NSW), Victoria, Queensland and Tasmania have recreational water monitoring programs applying to specific geographic areas and it was necessary to examine these programs in addition to guidelines and policies that apply in areas outside of these programs. Outside of areas managed by State departments or their programs, local governments are usually responsible for monitoring recreational water. This provides an additional layer of complexity which is not covered in this chapter. This chapter does not attempt to provide judgement on the appropriate level of microbiological indicators or other human health risks. It should also be noted that the examples provided in this case study are not exhaustive of the large variety of approaches taken by the many of local governments, water authorities and other bodies applying recreational water guidelines; but are descriptive of prevailing management practices in regions.

The remainder of this chapter comprises of five sections; Section 5.3 reviews recreational water quality monitoring in Australia focussing on monitoring for FIB, how this is communicated and inconsistencies identified between jurisdictions. Section 5.4 provides a discussion of Australian practice and guidelines, a comparison to the US, and describes some lessons on improved health outcomes in Australian recreational waters. Section 5.5 goes on to discuss the strategies which could be addressed in the national guidelines to provide better health outcomes drawing on examples from the USA and states in Australia who have initiated reforms in their guidelines. In doing so it discusses models of standardising water quality laws. Section 5.6 provides some concluding comments.

6.3 Recreational water quality monitoring of microbiological limits in Australia

6.3.1 Overview

NHMRC 2008 guidelines provide a process for assessment of microbiological risks in recreational water based on sanitary inspection and the measurement of microbiological indicators of faecal pollution over time. The FIB organism *enterococci* was chosen and limits based on 95 percentile microbiological water samples, generally taken over a period of time of approximately five years, were included in the NHMRC 2008 guidelines. This selection was based on WHO guidelines and studies which attempt to match the ‘response’ of gastrointestinal illness with the ‘dose’ as measured by the numbers of FIB in waters at the time of recreation. It is known that this dose response can change based on environmental factors as well as people’s own immune response to pathogens, for example, NHMRC 2008 guidelines do not apply to children. Other aspects which NHMRC 2008 does not cover are secondary contact recreation, such as kayaking or jetsking. They also do not provide a trigger value at which action should be taken when one sample is found to contain abnormally high numbers of FIB. This is because the approach taken is one of categorising risks based on the conditions as observed over time, rather than at a particular point in time.

Tables 5.1, 5.2 and 5.3 describe the application of NHMRC 2008 guidelines and recreational water guidelines in each Australian jurisdiction, policies and, in some cases, practices of larger water monitoring programs. It can be observed that in some circumstances NHMRC 2008 guidelines are closely followed and in other cases they are not. For comparison the US Environment Protection Agency (US EPA) 2012 Recreational Water Criteria are discussed in section 5.3.8 below.

Table 5.1: Australian microbiological recreational water quality standards, guidelines and guidance notes (ACT Government Health 2010, EPA Victoria 2003, Department of Health & The University of Western Australia 2007, NHMRC 2008, NSW Office of Environment and Heritage 2013, Department of Environment and Conservation (NSW) 2006, Queensland Government Department of Environment and Heritage Protection 2009, the Northern Territory Department of Health 2011, South Australian Government 2003, US EPA 2012,). All values organisms per 100ml unless otherwise stated.

Jurisdiction	Guideline	Daily forecast (usually summer months)			Weekly bacterial monitoring			Long term bacterial water quality		
Australia	NHMRC (2008) (Non-binding national guideline)	-			-			≤40[a]	A	-
								41- 200	B	-
								200-500	C	-
								>500	D	-
NSW (Sydney and Beach-watch)[b]	Daily/Weekly not based on any binding guideline. Long term based on NHMRC (2008).	Pollution unlikely	Green		≤40	Good	****	≤40	Very good (Green)	
		Pollution possible	Amber		41- 200	Fair	***	41- 200	Fair (Amber)	
		Pollution likely, avoid swimming	Red		200-500	Poor	**	200-500	Poor (Red)	
		Updated information available	Up-date		>500	Bad	*	>500	Very poor (Red)	
New South Wales (Other)	Water Quality Objectives for each Catchment and Marine Water Quality Objectives for NSW Ocean Waters[c]	-			Primary contact recreation: Max *enterococci* 100 per 100ml			150 faecal coliforms and 35 *enterococci*	Primary contact recreation median	
								<600 faecal coliforms	Primary contact 4/5 samples per month	
					Secondary contact recreation: Max *enterococci* 450-700 per 100ml			<1000 faecal coliforms and 230 *enterococci*	Secondary contact recreation median	
								<4000 faecal coliforms	Secondary contact 4/5 samples per month	

Jurisdiction	Guideline	Daily forecast (usually summer months)			Weekly bacterial monitoring			Long term bacterial water quality		
Victoria (Melbourne Metro - BeachReport (Port Phillip Bay) and Yarra-Watch)[d]	Daily/Weekly (swimming season) not based on any binding guideline. Long term based on State Environment Protection Policy (Waters of Victoria) (2003)	Suitable for swimming	Good		Ocean >200 *enterococci* (dry weather)[e]	One sample internal trigger	-	State Environment protection policy (Waters of Victoria) (2003)	75th percentile 150 *E.Coli* /100ml	-
		Good but caution if rainfall	Fair		>400	Two consecutive sample trigger				
		Avoid contact with the water	Poor		>1000, after dry weather	One sample impact indicator trigger				
		No data	N/A							
Victoria (Other)	State Environment Protection Policy (Waters of Victoria) (2003)	-			-			≤ 150 *E. Coli* OR 35 *enterococci*	Primary Contact Median of 5 samples ≤ 30 days	
								150 *enterococci* /100ml	Primary Contact75th percentile for 11 samples ≤ 60 days	
								≤ 1000 *E. Coli* OR 230 *enterococci*	Secondary contact Median of 5 samples ≤ 30 days	
ACT	ACT Guidelines for Recreational Water Quality (2010)	-			≥200	First sample trigger	Retest	-		
					≥200	Two consecutive sample trigger	Advise			

Jurisdiction	Guideline	Daily forecast (usually summer months)	Weekly bacterial monitoring			Long term bacterial water quality		
Tasmania (Hobart - Derwent Estuary Beach and Bay Watch)	-	-	As per Tasmanian Recreational Water Quality Guidelines			≤40	Good	
						41- 200 or 200-500	Fair	
						>500	Poor	
Tasmania (Other)	Tasmanian Recreational Water Quality Guidelines (2007)	-	1 test >140	Test again <48 hours	-	≤40	Good	
			2nd test >140	Issue advisory	-	41- 200 or 200-500	Fair	
			1 test >280	Issue advisory	-	>500	Poor	
South Australia	Environment Protection (Water Quality) Policy (2003)	-	-			150 *E. Coli* and 33 *enterococci*	Primary contact	-
						1000 *E. Coli*	Secondary contact	-
Northern Territory	Guidance Notes for Recreational Water Quality in the Northern Territory (2011)	-	<50 *enterococci*[f]	Open		Guidelines provide interim limits. NHMRC 2008 when sufficient data available		
			51-200 *enterococci*	Follow up/Open				
			Two samples <48 hours >200 *enterococci*	Advise public				

Jurisdiction	Guideline	Daily forecast (usually summer months)	Weekly bacterial monitoring			Long term bacterial water quality		
Queensland - (South East Queensland Healthy Waterplay)	Healthy Waterways Microbial Trigger Value Justification Paper (2014)	-	≥200 (Primary contact) ≥1000 (Secondary contact)	"Warning trigger" Resample <24 hrs Review observations Sanitary inspection		-		
			Either: Three consecutive days ≥200 (Primary contact) Or Two consecutive days ≥500 (Primary contact)	"Action trigger" Immediate temporary closure Resample <24 hrs Review observations Sanitary inspection etc				
Queensland (Other)	Various water quality objectives	-	≤40 *enterococci* per 100ml	-	-	-		
Western Australia	Microbial Quality of Recreational Water Guidance Notes (2007)	-	>200	Resample < 24hrs Review observations Sanitary Inspection	-	≤40	Very good, good (Green)	
						41- 200	Fair (Amber)	
			>400	Advise, resample < 24hrs, review observations, sanitary inspection	-	200-500, >500	Poor (Red)	

Notes: "-"represents not included in guideline or practice. a. NHMRC 2008 Table 5.7 provides microbiological classifications, sanitary and microbial rankings are combined to generate a rating of "Good – Green (Surveillance)", "Fair – Amber (Alert)" and "Poor – Red (Action)"; b. Two part assessment involving sanitary inspection and microbial water quality assessment category. (NSW Government Department of Environment Climate Change and Water 2010); c. (Department of Environment and Conservation (NSW) 2005); d. (EPA Victoria 2012); e. (EPA Victoria 2011); f. Based on two samples per month.

6.3.2 States and programs relying of methods not contained in NHMRC 2008 or their own guidelines

As described in Table 5.1 different limits for the FIB *enterococci* in primary contact recreation water are 33, 35, 40, 50, 140, 200, 280, 400, 500 and 1000 *enterococci* organisms per 100ml. NHMRC 2008 guidelines use *enterococci* as a FIB in marine and freshwater. Guidelines in Victoria and South Australia still use both *E. Coli* and *enterococci* as FIB and use different statistical methods and FIB for marine waters (*E. Coli*) to those used in NHMRC 2008 guidelines (State Government of Victoria 2014c).

Monitoring programs in Victoria, NSW and Queensland rely on weekly *enterococci* trigger value methods which are not included in NHMRC 2008 guidelines or their own state guidelines. Queensland Water Quality Guidelines (2009) refer to NHMRC 2008 as the default guideline if no guideline value is available. Water quality objectives refer to the value of a 95 percentile of less than or equal to 40 *enterococci* organisms per 100ml and therefore this value was included in Table 5.1. A more recent paper from Queensland body “Healthy Waterways” recommends trigger values for *enterococci* for both primary and secondary contact recreation.

Beachwatch NSW communicates weekly monitoring results based on Table 5.7 of the NHMRC 2008 guidelines. However there are also Water Quality Objectives for each Catchment and Marine Water Quality Objectives for NSW Ocean Waters which provide ‘example’ numerical criteria for waterways across the state. These include reference to numerical levels from ANZECC 2000 Guidelines as well as values, which Beachwatch NSW no longer recommend.

In Queensland, policies and guidelines are almost silent on recreational water quality. It therefore falls on specific councils to decide whether to follow the national guidelines or local and state guidelines on a case by case basis. In this case the Healthy Waterways program provides additional guidance for South East Queensland and this was included in the review undertaken in this thesis.

6.3.3 Limits (trigger values) for short term or weekly monitoring

To decide when to close a beach for recreation, most states rely on one and two sample trigger values. These are limits that, if a single sample is over the trigger limit a management action will be triggered. The management actions are either taking a second sample (with a public warning for another high sample) or issuing public warning. Interestingly, NHMRC 2008 does not provide single sample trigger values.

Differences exist between states with respect to the limits and management actions. Guidelines in Tasmania (excluding Derwent Beachwatch) and the ACT rely solely on the one and two sample *enterococci* per 100ml triggers, with ACT using only a single numerical limit (200) and Tasmania using its own unique limits (140 and 280) (Tasmanian Government Department of Health and Human Services 2007). Beach Report Victoria also apply their own numerical limits at (200, 400, 1000) (EPA Victoria 2011).

Western Australia has developed an 'Enterotester' tool which allows microbial testing data to be entered to generate site specific trigger values and values for which two samples in a row must be higher than the trigger management action (Abbott et al. 2011). It enables calculation of 95 percentile value, accounts for different sized sample sets (large and smaller), and calculates one sample and two sample site specific trigger values. Generic microbiological trigger values (at 200 and 400) are also provided within Microbial Quality of Recreational Water Guidance Notes (2007) where insufficient data is available (Department of Health & The University of Western Australia 2007).

Healthy Waterways Queensland recently created microbial trigger guidance (not an enforceable set of criteria) to be used in addition to NHMRC 2008 in South East Queensland, in order to create consistent short term recreational water management limits for both primary and secondary recreation to be used in addition to NHMRC 2008 in South East Queensland. They provide their own system of warning triggers based on *enterococci* (200 primary, 1000 secondary) requiring further testing, and for primary contact recreation, an action trigger (500 for two days, 200 for three days) for closure and a flow chart describing action to be taken. If more than three consecutive daily samples fall into the "warning trigger" category they will be upgraded to an "action trigger"; meaning advisories are issued for primary contact recreation (Healthy Waterplay 2014).

The Northern Territory Guidance Notes for Recreational Water Quality in the Northern Territory (2011) adopts NHMRC 2008 when sufficient data are available, and generic trigger levels for fortnightly monitoring are matched to a traffic light system, although these values are for weekly tests and do not correspond with NHMRC 2008 (Northern Territory Department of Health 2011).

For secondary contact recreation waters which are over the relevant warning value, Healthy Waterways (Queensland) provide a risk matrix which local officers can apply to waters. It considers vulnerability of users, number of people, exposure of activities, likelihood of infection and then gives a health risk, for which the highest two categories will result in equal closure scenarios. A risk matrix for secondary contact recreation provides an opportunity for smaller jurisdictions because if there are limited users, and low exposure risk, then overall risk is predicted to be low and water can remain open based on the balance of risk (Healthy Waterplay 2014).

6.3.4 Daily predictive water quality warnings

Table 5.1 shows that South Australia, Victoria and New South Wales all have daily alert programs which provide information daily during designated swimming seasons utilising environmental information, such as rainfall, to predict when water quality may decline. Outside these services, lay people are exposed to unknown and potentially very high risks to their health.

In bathing season in Victoria around the Melbourne metro area, Beachwatch and Yarrawatch (EPA Victoria) provide a daily rating for 36 metropolitan beaches in Port Phillip Bay and four Yarra River locations twice daily from December to March. These projects rely on Twitter and local life savers (at 10 beaches) to promote rankings (State Government of Victoria 2014a). In South Australia, WaterConnect (EPA South Australia, https://www.waterconnect.sa.gov.au) monitors stormwater flow in coastal waters in addition to microbiological monitoring programs and provides an unverified dataset of potential stormwater flow. The South Australia EPA publishes a "Caution" sign on a map online and via email but by subscription (Government of South Australia 2014). In NSW, Beachwatch gives daily water quality forecasts based around modelling rainfall and the previous five years of monitoring data. The program produces water quality predictions based on modelling of the previous 5 years of microbiological monitoring results and rainfall data (rainfall threshold) and current data from 40 rain gauges. A weekly star rating is provided using one *enterococci* sample result and provides stars based on NHMRC 2008 suggested values (Table 5.7). Long term beach grades based on NHMRC 2008 guidelines are updated yearly, at 127 swimming locations in Sydney by Beachwatch plus 129 council sites (NSW Government Department of Environment and Heritage 2014). While this sounds comprehensive, outside of these areas large areas including Australia's more populated towns are left unmonitored.

6.3.5 General warnings following rain

Outside of these the daily pollution warning programs, departments rely on providing general warnings against swimming after rain. General warnings for not swimming after rainfall range from five days in Tasmania (Tasmanian Government Department of Health and Human Services 2014), one to two days in Victoria (State Government of Victoria 2014b). New South Wales Beachwatch recommends avoiding water for one day for ocean and three days for Harbour beaches (NSW Government Department of Environment and Heritage 2014). In Queensland the Health Waterways program recommends one day for open waterways and beaches and three for rivers lakes and oceans and includes swimming, surfing and secondary contact through jet skiing (Healthy Waterways 2014), the Northern Territory recommends three days for waters classified as "good" under their guidelines (Northern Territory Department of Health 2011). Whereas in Western Australia the warnings are based on NHMRC 2008 guidelines for water quality, so that users are advised to stay away for between three days and one week following heavy rainfall (greater than 10mm) depending on the ranking of the waterbody (Department of Health & The University of Western Australia 2007). Again, gross inconsistency applies within and between jurisdictions.

6.3.6 Communication and use of the traffic light system

Table 5.1 shows that a variety of symbols and methods of communication. A traffic light symbol is included in Table 5.3 to represent states using variations on the green, amber, red method of communicating risk. As seen in Table 5.1 NSW Beachwatch utilises NHMRC 2008 guidelines for weekly water quality reporting but have applied their own weekly star rating, and for the long term, a traffic light communication. In Queensland local variation applies. For example in Moreton Bay, signage uses colours to represent NHMRC 2008 in a similar manner to Western Australia and New South Wales (Beachwatch), albeit with their own system of some ticks and exclamation marks. By contrast, in neighboring Brisbane City Council, another system is used. The ACT uses a grading system of extreme, high, medium and low to classify primary and secondary contact recreation areas for the risk of algae which are harmful to human health. Microbiological risks are classified as either "open" or "closed" (ACT Government Health 2010). Queensland Water Quality Guidelines also contain a traffic light warning criteria for blue green algae in recreational waters (Queensland Government Department of Environment and Heritage Protection 2009).

Moreton Bay Council (Queensland) uses another variation of the traffic light approach with its own unique symbols (not listed in Table 5.1 or 5.2) to represent compliance with NHMRC 2008 Table 5.7 (Moreton Bay Regional Council 2014). By comparison, neighbouring Brisbane City Council posts a 'general information sign' warning that the waterway is affected by 'high levels of bacteria at certain times, especially after heavy rainfall'. It warns against swimming, jet skiing, kite surfing and 'any activity where you may swallow water and have your face frequently wet'. Brisbane also uses a 'temporary warning sign' reporting that high levels of bacteria have been recorded and advising against contact with the water. The council's website notes that; 'The *enterococci* trigger levels for installing and removing the warning signs are based on those in the National Guidelines for Managing Risks in Recreational Waters, 2008' (Brisbane City Council 2014).

Table 5.2: States that display information on beach water quality online through periodically updated webpages, reports, media or signage

State	Description
Western Australia, Department of Health	Temporary 'Beach grades' assigned for both metropolitan and regional sites are presented on the Western Australia Department of Public Health website (Government of Western Australia Department of Health 2014)
Tasmania, Department of Health and Human Services	Weekly monitoring data from local governments is carried out (usually weekly, (some fortnightly) and usually between November or December and March) is reported yearly. Derwent Bay Watch (Hobart and surrounds) uses a website to advertise weekly and long term recreational water quality results (Derwent Estuary Program 2014, Tasmanian Government Department of Health and Human Services 2014)
Queensland	Local governments conduct monitoring and some (eg Moreton Bay Council) publish results online while others (eg Gold Coast Council) publish only general information online
Northern Territory, Department of Health	Yearly data and beach closure advisories based on *enterococci* data collected from 12 beaches in Darwin Harbour (1 June – 30 September) by the Department of Land Resource Management (Northern Territory Department of Health 2013)
ACT, Territory and Municipal Services (TAMS) and National Capital Authority	Weekly monitoring of some areas is carried out by Territory and Municipal Services (TAMS) (ACT Government Territory and Municipal Services 2014) National Capital Authority monitors Lake Burley Griffin including weekly reports for the swimming season (mid-October to mid-April) (National Capital Authority 2014)

Table 5.2 provides a summary of how states (other than beachwatch style programs) deliver online communication of water quality. It is noteworthy that Australia's capital cities have online water quality information available, whereas tourist destinations such as Byron Bay and the Gold Coast do not. Table 5.3 provides a simplified overview of Table 5.1 and Table 5.2. This is provided in order to identify themes in recreational water management and to assist in tracking variation in methods used. When referring to 'following NHMRC 2008' this is interpreted as the standard of recreational water quality set by Western Australia and NSW Beachwatch, that is, conducting regular sanitary inspections in addition to microbial water quality indicators based on the recommended data set.

Table 5.3: Summary of recreational water quality monitoring guidelines and programs in Australia

		Long term grade		Weekly tests		Daily forecast
		NHMRC 2008	Other (other FIB, rolling percentiles etc)[a]	"Applying" NHMRC 2008 Table 5.7[b]	One/Two sample triggers and maximums	Prediction of likelihood of pollution based on rainfall
Australia	NHMRC 2008	✓	-	-	-	-
WA	Microbial Quality of Recreational Water Guidance Notes (2007)	✓	-	✓	✓	-
NSW	Beach Watch	✓	-	✓ (star rating)	-	✓
	Water Quality Objectives (each catchment and ocean)	-	✓	-	✓	-
VIC	State Environment Protection Policy (Waters of Victoria) 2003	-	✓	-	-	-
	Beach Watch (Port Phillip, Yarra)	-	✓	-	✓	✓
SA	Environment Protection (Water Quality) Policy 2003)	-	✓	-	-	-
	EPA Stormwater warnings	-	-	-	-	✓
QLD	Healthy Waterways Microbial Trigger Value Justification Paper (2014) (South East Queensland Program)	-	-	-	✓	-
	Water Quality Objectives (Various)	-	✓	-[c]	-	-
ACT	ACT Guidelines for Recreational Water Quality	-	-	-	✓	
NT	Guidance Notes for Recreational Water Quality in the Northern Territory (2011)	-	-	-	✓	-
Tas	Recreational Water Quality Guidelines 2007	-	-	-	✓	-
	Derwent Beach Watch (Hobart - Derwent Estuary Beach and Bay Watch)	✓	-	-	✓	-

Notes: a. Using *E. Coli*, faecal coliforms, rolling percentiles or median (Victoria State Environment Protection Policy (Waters of Victoria) 2003, South Australia (Environment Protection (Water Quality) Policy 2003); b. This is not the express intention of Table 5.7 NHMRC 2008 but has been adapted in many regions; c. For the column "applying NHMRC Table 5.7" there is variation within some states, for example, Brisbane City Council and Moreton Bay Council in Queensland take different approaches, described below. For this reason Table 5.3 also lists Beachwatch style programs and guidelines.

6.3.7 Intra-jurisdictional variation in the application of NHMRC 2008 guidelines

The following differences in application of the NHMRC 2008 guidelines are identified through Tables 5.1, 5.2 and 5.3;

- Short term limits for beach closures and advisories where one or a small number of samples are high
- Procedures for communicating risk when programs have not been established for five year and as a result 100 data points (samples) are not available should be included in national guidelines
- Replication within samples and monitoring procedures vary
- Variation between states exists for communication within the use of traffic light system. If traffic lights are used to communicate risk there is variation in what colours and symbols are used, and what colours represent. For example, some states use "green" to show testing is done under full NHMRC 2008 (all matrixes, 100 data points), others use only the microbiological limits, and other versions exist for example likelihood of stormwater pollution
- Use of *enterococci* as FIB is not universal. The same holds for *E. Coli* and faecal coliforms
- Public access to actual data varies from full access within days, to yearly summaries to no access unless requested, or no data at all
- NHMRC 2008 microbiological matrix (Table 5.7) is included in the guidelines but not other elements such as sanitary inspection
- Statistical methods vary, for example, Enterotester, median, 95 percentile or 75 percentile
- Secondary contact recreation is not managed at all in some cases

- Levels of guidance as to what constitutes a sanitary inspection are lacking (Abbott et al. 2011)

Despite these inconsistencies and malaise induced by undemanding guidelines, there are cases of advanced recreational water quality monitoring in use by Australian States and the US (not in NHMRC 2008 guidelines). For example;

- Weekly ranking and long term (NHMRC) ranking utilizing some version of traffic light
- Limits which trigger management action where one or two samples contain high numbers of FIB
- Secondary contact recreation limits and use of a secondary contact recreation risk matrix (sanitary inspection)
- Predictions based on a combination of sanitary inspection combined with current rain or stormwater levels (mentioned in NHMRC 2008 but not taken up everywhere)
- Beachwatch programs which support local government implementation and standardization and storage of data
- Quantitative microbial risk assessments and microbial source tracking
- Recreational water quality monitoring advanced on NHMRC 2008 and used in international jurisdictions includes rapid methods of detecting microbiological pollution in water, and national central collection of data encouraged by grants, as discussed in section 5.3.8 of this chapter.

Noteworthy amongst these advances is the Queensland Microbial Trigger Value Justification Paper which defines primary contact recreation more broadly than many regulators may understand this to be. For example, including activities traditionally seen as secondary contact recreation based on exposure, not assumption.

6.3.8 Recreational water quality monitoring in USA

In the US, the *Federal Water Pollution Control Act Amendments of 1972* (referred to as the ‘Clean Water Act’) makes all discharges to water illegal and requires a permit for operating a discharge. Criteria and standards are set at a federal level and these are carried out by the states with provisions for federal financial support (Copeland 1999). The *Beaches Environmental Assessment and Coastal Health Act (2000*) (Beach Act) amended the *Clean Water Act* to require the US EPA to create criteria for faecal indicator bacteria, states adopt these criteria, monitor beaches, and to warn the public if levels indicate the area is unsafe for recreation. In 2012 this amounted to 3762 coastal and Great Lake beaches (United States Environmental Protection Agency 2013). In order to support this the US EPA is also given the power to give grants to support coastal water quality monitoring (*Clean Water Act* s. 406). In 2014, US EPA estimated it would give $9,549,000 of grants (US EPA 2014). By accepting the grant the State is then required to comply with reporting requirements (*Clean Water Act* s. 406). Section 5.4 of this chapter proposes novel policy options based on US and other experience which may assist Australia to overcome constitutional issues and become move towards consistency.

Boehm et al (2009) summarised research on the former 1986 US EPA recreational water criteria, highlighting that relationships of faecal indicator bacteria to recreational water illness are not well established for all waters such that different criteria should be created for different types of waters and risks. With respect to pathogen concentrations, for which pathogens are actually causing the illness, they only relate to gastrointestinal illness and not the range of other illnesses or vulnerable people and children, and they reflect an acceptable risk which was decided without asking the public what risk was accepted. Further, they argue the methods applied here (and in Australia) are slow and that single samples do not reflect water quality which often is extremely variable. This may lead to Type 1 and Type 2 errors, that is, waters may be either open when it is not safe or closed for no reason (Boehm 2007, Boehm et al. 2009). Type 1 errors leave open the possibility of human illness, Type 2 errors deprive citizens of recreational values for no reason. In either case this is a sub-optimal outcome for marine recreators, and this group is worse off from this poor management.

Through the *Beach Act* US EPA also initiated research required to update recreational water criteria in 2000. This has resulted in the development of more rapid methods of detecting microorganisms in recreational water and the use of these to predict swimming associated health impacts (Wade et al. 2006).

A point of comparison between Australian national guidelines and US national criteria are the recommendation of procedures when a single high sample is returned. US EPA 2012 Recreational Water Quality Criteria presents a different approach to that used in NHMRC 2008 which in theory should be applied in future state guidelines. The main limits to be included in State’s guidelines are magnitude criteria involving geometric mean and statistical threshold values for *enterococci*. However, a beach action value is also included as an optional value that states can use to make decisions on whether to close a beach with a single high sample.

US EPA 2012 Recreational Water Quality Criteria (2012) provide two choices based on illness rates;

- 32 illnesses per 1000 primary contact recreators

- *Enterococci* GM[8] 30, STV[9] 110, *E. coli* 100 STV 320 (cfu[10]/100ml)

Beach Action Value; *Enterococci* (culturable) – 60 cfu, E.Coli – 190 cfu, *Enterococci* QPCR[11] – 640 cce[12].

- 36 illnesses per 1000 primary contact recreators

- Enterococci GM 35, STV 130, *E. coli* 126 STV 410 (cfu/100ml)

Beach Action Value; Beach action value: *Enterococci* (culturable) – 70 cfu, E.Coli – 235 cfu, *Enterococci* QPCR – 1000 cce.

The illness rate of 36 per 1000 represents a 1986 criterion and therefore the lower rate represents an advancement of water quality (US EPA 2012).

With respect to implementation, the *Clean Water Act* criteria were not taken up by all US States, which led to the *Beach Act*. However not all states had achieved the Beach Act requirements, which led the US EPA to pass the Bacteria Rule ("Water Quality Standards for Coastal and Great Lakes Recreation Waters" 2004). The rule put in place protections in the states that had not either adopted US EPA's criteria or adopted modified versions or site specific guidelines, based on scientific evidence, which have been approved by US EPA. It is noted that approaches to recreational water warnings also vary between US states, and that funding and other issues may cause issues for implementation of these national guidelines. However, this thesis does not explore implementation of US water quality guidelines.

6.4 Lessons for improved health outcomes in Australian recreational waters

6.4.1 Overview

Table 5.4 provides an overview of five problem areas which may cause Australian recreational water quality management may not be optimal. Immediately following Table 5.4, an overview is provided where these areas are reviewed in greater detail. The identified solutions are canvassed briefly in this section of the chapter, and returned to in Section 5.5, which discusses the model and barriers to reforms

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[8] Geometric Mean
[9] Statistical Threshold Value
[10] Colony forming units
[11] Quantitative Polymerase Chain Reaction; a genetic method, used to determine the microbial pollution in water and described further below
[12] Calibrator cell equivalent

Table 5.4: Overview of problem areas in Australian recreational water quality monitoring and potential consequences for society

Identified problem	Summary of problem	Identified solutions
1. Do NHMRC 2008 guidelines achieve national consistency?	Lack of guidance in NHMRC 2008 guidelines in some areas has led states to take their own approaches to fill the gaps. These issues have been described previously in this chapter. In summary; • Sanitary inspections, definitions in risk classification (Abbott et al. 2011) • Absence of short term trigger values (Table 5.1) • Absence of secondary contact recreation	• Standardising monitoring procedures by providing national guidance for most advanced states • Further solutions discussed in Table 5.5
2. Do assumptions and uncertainty within guidelines and practice create problems?	When guidelines were developed certain assumptions were made to fill gaps in knowledge. These may produce issues for some users. • Risk to children may be underestimated (Wade et al. 2008) • Possibility of waters remaining open or closed at wrong times due to one-two day testing period (Wade et al. 2006) • Result of single water samples may not give reliable enough estimate to close or open beach (Boehm et al. 2002, Whitman & Nevers 2004) due to extreme spatial and temporal variability of FIB in water (Boehm et al. 2002, Whitman & Nevers 2004, Boehm 2007, Amorim et al. 2014) • Study required to determine actual disease burden rather than assumption (Lepesteur et al. 2006)	Optional methods for advanced states should be included in reformed of NHMRC guidelines, in order to ensure consistency, including ; • Rapid genetic methods (Griffith & Weisberg 2011) • Modelling and risk assessment
3. What role does public perception and behaviour play in safety?	A range of factors such as age, background and absence of warning signs for poor recreational water quality can influence whether people will swim and therefore impacts risk (Lepesteur et al. 2008). Behaviours may increase risk where a large proportion of recreators in an area fall outside guidelines (eg children, elderly) (Lepesteur et al. 2008).	Communication to be included in national guidelines Further study to understand risk (Lepesteur et al. 2008)
4. Does poor communication increase duty of care?	Inadequate communication of recreational water risks or insufficient monitoring of risks may create a risk for swimmers who are reliant on governments to inform them when government run infrastructure creates a higher than normal risk, for example, sewage spills	Demonstrates that it is better to remove risks (for example, by reducing wastewater discharge through wastewater reuse) than manage them through monitoring Further study to determine disease burden in relationship to monitoring program

5. Do recreational water guidelines effectively inform investment decisions?	Beachwatch programs provide greater information for decision makers when prioritising both investment decisions and health and safety decisions (NSW Government Department of Environment and Heritage 2014) Caution against using lack of information on risk to justify inaction where the monitoring program is below national standard	Smaller jurisdictions and regions can provide greater health protection if develop predicative warnings for known risks instead of relying on single weekly samples

6.4.2 Effectiveness of NHMRC 2008 guidelines in achieving consistency

Australian water quality guidelines recognise the flexibility that local variation requires, however Table 5.1 shows that the levels of FIB and the timing and manner of warnings one receives varies depending on which State or suburb you are swimming in.

Commentary suggests that the NHMRC 2008 guidelines which combine sanitary inspection with microbiological classification is effective but with limitations including absence of a template for sanitary inspections, absence of definitions of the final risk classifications in NHMRC 2008 guidelines. This has led Western Australia to develop a traffic light system with generic definitions of risk as the Enterotester spreadsheet (Abbott et al. 2011). Perhaps predictably, since 2008 other states have also moved to overcome these shortcomings. Table 5.1 describes how similar methods of communication are used in various jurisdictions to represent a variety of things, and further, that some jurisdictions recommend single and two sample trigger values. This variation is potentially leading to public confusion.

Standardizing monitoring procedures brings funding and logistical issues in some areas, and a lack of flexibility (for example when evidence is collected demonstrating lower risk). However, in turn standardised monitoring processes provide increased accuracy for assessment of health risks and for how health risks vary between beaches (Nevers & Whitman 2010). From a policy perspective, there is a danger that some states are choosing to apply a higher risk threshold than recommended by the NHMRC 2008 guidelines, potentially providing inaccurate comparisons of recreational water safety when compared to more advanced states.

6.4.3 Overcoming assumptions and uncertainty

In some areas where recreational water quality testing relies solely on weekly microbiological testing there is a possibility of underestimation or overestimation of risk. FIB concentrations at coastal and inland beaches have been shown to be highly variable over time and space (Boehm et al. 2002, Whitman & Nevers 2004, Boehm 2007, Amorim et al. 2014). In coastal waters, ‘extreme variability’ for *enterococci* has been described (Boehm 2007), raising concerns about the ability for responsible agencies to make decisions on whether to open or close a beach based on methodologies (applied in many Australian states) relying on single samples of water taken weekly (Boehm et al. 2002, Whitman & Nevers 2004).

Proper use of microbiological data combined with sanitary inspection can lead to more efficient management because understanding of circumstances when water will have high microbiological numbers allows reduced microbiological monitoring (Ashbolt & Bruno 2003). However, the accuracy of risk assessments for recreational waters will vary based on existing knowledge. Inaccuracies result from inadequate information available on pathogen survival compared to FIB survival, knowledge of dose-response models, and variation of behaviours in different regions, for example, longer exposure in warmer water (Tseng & Jiang 2012).

Recreational water impacted by human faecal matter may have higher risks than waters impacted by faecal material from other animals (Soller et al. 2010), lending support to management approaches providing site specific criteria, particularly where no or low sources of human pollution would lead to overestimates of risk (Soller et al. 2014). On the other hand current methods used in Australia may underestimate the risk to children, where one US study showed higher susceptibility for illness in children under 10 years old in freshwaters impacted by human pollution (Wade et al. 2008). Methods for microbiological testing which require 24 to 48 hours for any subsequent closure or management action may lead to decision errors for waters being open or closed when they do not need to be (Wade et al. 2006). Moreover, recreational water illness may be underreported because they are self-limiting and many do not require hospital treatment (Boehm et al. 2009).

Another method of overcoming this uncertainty is to use predictive modelling of FIB in combination with other methodologies. Although, predicative modelling may not promote reduced decision errors at all beaches; a Chicago USA study found greater accuracy for some beaches when predictive modelling was combined with site specific single sample (Nevers & Whitman 2011).

Quantitative Microbial Risk Assessment (QMRA) can assist with scenario planning in decision making and accounting for local variations that impact water quality such as multiple sources of contamination, spatial and temporal variation in FIB, and fluctuating relationships between FIB and pathogens (Ashbolt et al. 2010). However the accuracy of QMRA is subject to limitations where there are gaps in current knowledge on recreational water risks and illness (Boehm et al. 2009). Management actions beyond guidelines may be justified in some circumstances, for example, one study revealed that only 31 percent of participants were healthy adults to whom the guidelines applied (Lepesteur et al. 2006). Assumptions used in some recreational water decision making decrease the reliability of those decisions and this could be improved through studies which consider actual disease burdens and utilize social surveys to determine additional factors which increase or decrease risk (Lepesteur et al. 2006).

Rapid measures of water quality (using a genetic method called quantitative polymerase chain reaction or 'QPCR') are capable of predicting recreational water illness, meaning faster detection of elevated levels of microorganisms and therefore more accurate decision making on when to open or close beaches (Wade et al. 2006, Wade et al. 2008, Wade et al. 2010). Advantages are seen as a slower lag time between testing and management action (same day warnings achieved by 11.30am) with the main challenges being cost and issues of implementation include the physical logistics of collecting, processing and analyzing samples to ensure warnings are actually posted before or at least during swimmer exposure to the water (Griffith & Weisberg 2011).

6.4.4 Managing and understanding public perception and behaviour

As methods develop further and managers are able to gain local information such as sources of faecal indicator bacteria, it seems likely that these managers would wish to apply specific criteria to some waters. To do this without an understanding of societal preferences for risk at the location or the economic implications of management action, adds another assumption to the practice of recreational water quality management.

Public perception of water quality impacts the choice of whether to enter the water or not and therefore presents another layer of variability on recreational water safety. Personal perception, local knowledge, absence of warnings and signage, age and residency can all influence recreation behaviours and choices and therefore exposure to risk (Lepesteur et al. 2008). Behaviours and social factors driving recreational risk are absent from guidelines. Public perception of water quality may not reflect actual water quality. In one Los Angeles study, the public perceived water quality to be lower than actual water quality with other factors being more influential than factual information through public education campaigns (Pendleton et al. 2001). A study of waters possessing risk in Western Australia found there was a perception of risk but a lack of behavioral change indicating that the seriousness of the risks was underestimated (Lepesteur et al. 2008) In another study, from the UK, water quality was one of a number of factors considered and decisions to enter the water were found to be influenced by experience (Ravenscroft & Church 2011).

Because the one and two sample limits now applied by many programs are still retrospective (taking a minimum of 24 hours to provide results), funding for research towards rapid microbiological testing methods is a necessary consideration. The US guidelines provide an example as to how monitoring advances can be included in guidelines or criteria to support more advanced states without reducing flexibility for smaller jurisdictions who cannot meet advanced standards.

6.4.5 Does poor communication raise the duty of care?

A legal question for future research is whether agencies owe a duty of care to recreational water users. Do programs providing less information necessarily increase their required level of care (compared to more advanced programs) by creating a reliance on no swimming warnings as opposed to informed choice? And further, could someone with a recreational water illness make a claim in negligence where management authorities operate infrastructure which creates a risk in recreational waters (for example, sanitary sewer overflows) but fail to notify the public of overflows.

Other factors relevant to the question of whether recreational water management impacts duty of care for swimmers include; 1) the potential for confusion due to differences between communication and when a warning is issued, 2) variation between when and where members of the public are able to freely access monitoring results, and 3) variation in what risks are warned against, with only some states developing daily warning systems and the potential for people to assume a lack of warning equates to safety.

Programs such as those described in NSW, Victoria and South Australia prioritise communication of risks as a means of increasing safety in recreational water by giving the public access to information so that they can make an informed choice about when to swim. Outside the three states which issue daily predictions, all other areas swimmers rely on the weekly microbiological monitoring and general warnings about not swimming after rain.

It is important that managers understand and establish the overall goal of monitoring programs (Nevers & Whitman, 2009). In some circumstances citizens may not have enough information to make informed assessment based on ordinary communication strategies and therefore more extensive communication may be justified. For example, where untreated wastewater infrastructure is diverted to recreational water areas and where there are vulnerable individuals in these areas who may not be able to interpret complex information of make a fully informed decision, demonstrating the importance of clear and consistent signage.

6.4.6 NHMRC 2008 guidelines establish knowledge to inform investment decisions

Programs such as NSW Beachwatch claim to allow for investment on wastewater or stormwater infrastructure to be prioritised (NSW Government Department of Environment and Heritage 2014). For example, investment in water quality improvement will be a lower priority if a waterbody has good microbiological quality most of the time but there are a smaller number of times of much higher risk, and where risk can be reduced through communication. NHMRC 2008 guidelines provide the method of categorizing risks so that local actions can be taken such as signage or identifying stormwater discharges. There are examples of this through several of the programs discussed which provide warnings for specific high risk events. In NSW wastewater treatment licences under environmental legislation apply to the whole of the system, including sanitary overflow points. An international example of taking this one step further is the diversion of dry weather runoff to wastewater treatment facility by Orange County Sanitation District.

In situations like in Launceston, Tasmania with occasional untreated discharges of sewage, a secondary contact recreation area (in which no recreational water risks are monitored, absence of evidence of recreational health impacts and no notification is required) should not be used to justify inaction where there is no effort made to identify health risks. Arguably, overreliance on flexibility in guidelines creates a negative feedback loop supporting underinvestment whereby less monitoring effort or closure of water allows it to remain degraded; a situation specifically discouraged by NHMRC 2008 guidelines. Whereas in more advanced states, flexibility may be used to take action once evidence of lower risk is collected, it is concerning that in states where microbiological monitoring effort is a less than recommended in NHMRC 2008, an absence of scientific evidence of risk may be used to support not taking management action.

In most areas authorities already have a duty to report malfunctions, discharges and spills and therefore this information should also be available to the public. As a minimum, planned occasional untreated discharges to areas popular for secondary contact recreation should be automated so that an email or other automatic warning system can be established. One role of Beachwatch (run by the NSW Office of Environment and Heritage) is to communicate this data to the public. They also assist with sample media releases, training, sanitary inspections and weekly and long term rankings.

6.5 Model of standardising water quality laws

Setting microbiological standards for waters used for recreation should be simple; national guidelines are made, states either adopt these, a version of these, or take another approach where there is scientific evidence to support this. NHMRC 2008 guidelines are implemented differently by each State in several areas including recreational water quality and biosolids management. The level of health protection varies and it is inefficient to continually redevelop and apply different guidelines for every state. Constitutional issues mean no state can be forced to follow a national approach and therefore if consistency is a desired outcome, either agreement or financial incentives or support may be necessary.

Table 5.5 provides six potential issues and barriers to implementing these concepts for reform and provides advice on how or if these may be overcome. The Southern California Coastal Water Research Project (SCCWRP) was created by multiple agencies. It conducts coastal environmental research and participates in management strategies and building consensus amongst experts (Mearns et al. 1999). The project is listed as a policy option example under issue 6 of Table 5.5. Following the passing of the Bacteria Rule 2004, (discussed above) SCCWRP developed science and validation of methods so that California beach managers could move towards the rapid assessment and characterization of beach water quality risks. The project included the creation of a Rapid Methods Task Force and conducting a pilot study for rapid microbiological methods (Griffith & Weisberg 2011). SCCWRP demonstrates advantages of a multiagency approach to filling knowledge gaps in areas like water quality management with interlaced dimensions of science and policy.

Table 5.5: Predicted issues for implementing more consistent water quality guidelines in Australia and suggestions for implementing these

Issue/ Barrier	**Reform**
1. Support from community Likely to support but also want stricter guidelines than government may want	Potentially different for different groups in society. Requires social science research.
2. State government support May be concerned about costs, decreased compliance or ability to implement	State which elements are mandatory for parties seeking funding and claiming to be compliant (for example; consistent signage, *enterococci* limits, weekly sampling) and which are included to support more advanced states (eg like is done in US EPA guidelines with rapid microbiological testing).
3. Legal barriers Constitution does not give power to create laws on water to federal government	Requires state government agreement. The best option is Council of Australia Governments (COAG) agreement resulting in binding mechanisms however incentives may be more realistic.

4. Implementation by local government or small areas Financial costs, technical issues	Funding from Federal Government for smaller governing bodies, in the form of a grant scheme and money towards assisting in implementation and training. Funding from federal government would come with agreement for reporting to a federal database in a consistent manner. Federal government financial support in the form of a grant scheme would assist this.
5. Different circumstances Need to account for variation in circumstances in some states	National guidelines could provide clarity as what constitutes basic minimum implementation requirements.
6. Agreement between regulators Gaps in knowledge	Funding for research organisations to inform this process, potentially through a collaborative Southern California Coastal Water Research Project (SCCWRP) style approach, based on implementation of research in key knowledge gaps.

Issue 4 and issue 2 in Table 5.5 refers to a federal grant scheme as used in the US for recreational water monitoring. Under this grant when receiving funding parties are required to report monitoring results to a federal register under a uniform reporting standard, this would require no constitutional reform and would provide incentives for all states to cooperate. Issue five relates to implementation of technical matters. Smaller jurisdictions do not have equal resources compared to beach watch programs. Programs which support local government in implementation (such as Beachwatch NSW) have demonstrated benefits producing a larger area of uniform communication, more efficiency and better trained local government officers. Although this would cost some money initially, it may result in efficiencies by ensuring states and jurisdictions are not using resources to create multiple versions of this system with slight variations, and it could be argued that the current situation is inefficient in many cases where microbiological monitoring is ineffective. In order to overcome the problem of different levels of participation by some states, Issue 2 of Table 5.4 refers to the flexibility to accommodate different circumstances (in line with NWQMS) built into guidelines, and guidelines should list sections which are necessary for state compliance.

Constitutional barriers which prevent national criteria being drafted are not fatal to progress towards uniformity, for example, amendments which could be made to the guidelines to support this. Additional actions to support this could include Council of Australia Governments (COAG) agreement between the States, Territories and Commonwealth Government which could allow national water quality guidelines to be binding within states, or at the minimum a commitment to bring their own guidelines in line with national standards (see discussion below on challenges of this). While it is possible to achieve agreement through COAG so that national guidelines apply in each State, it can be difficult.

Other notable developments in the US which are of relevance to Australia include recent moves towards cooperative approaches to water quality monitoring, such as the Unified Beach Water Quality Monitoring and Assessment Program in South Orange County. This is a collaboration of three agencies, aims to ensure consistency for monitoring and monitoring objectives, and was informed by a stakeholder consultation (California Water Boards 2014).

The harmonization of Occupational Health and Safety (OH&S) laws under COAG in reality was a 30 year process in which it was attempted to simplify the 400 Acts and other instruments which once existed across Australian jurisdictions adopting model laws and codes as well as adopting universal enforcement and compliance policies (Windholz 2013). The length of this process demonstrates the difficulty in getting cooperation from Australian states in setting uniform laws. One positive difference between OH&S and recreational water is that it is possible that there would be less controversy and costs involved in providing more information on water quality; who would argue people should be given less information? The cost is to government departments and entities only. Therefore it can be determined and a level of risk can be chosen with reference to expected increases in costs.

6.6 Conclusion

NHMRC 2008 guidelines aim to achieve consistency in recreational water quality management. This has not occurred. Every Australian State and Territory takes a unique approach to communicating microbiological recreational water quality risks to the public. States have developed their own practices to fill gaps in NHMRC 2008 guidelines. For example, innovations include monitoring programs led by state government departments facilitating consistent reporting between local government areas (NSW), accessible spreadsheets for determining site specific values (Western Australia), short term water quality indicators or the use of one and two sample trigger values for these weekly tests (ACT, Western Australia, the Northern Territory, Tasmania, and beachwatch style programs in NSW, Victoria and South East Queensland), the use of a risk assessments specific to secondary contact recreation (Queensland), communication of weekly microbiological warnings, and consistent sanitary survey methodology. Some states have found it necessary to go beyond the national guidelines, whereas other states appear to consider the national guidelines as a list of optional actions (as opposed to a program to be followed). A policy approach at the very least, to ensure consistency as states adopt practices, is to include guidance for best practice management.

Furthermore, communication of risk is an important part of risk management and the use of inconsistent levels of risk and communication (signs, or lack of communication) has the potential to mislead the public when they are attempting to make informed choices. It would be desirable for a more consistent level of acceptable risk to be settled on. This applies both between states and additionally there appears to be little justification for protecting swimmers and not protecting other recreational water users. There are a range of ways for the Commonwealth Government to lead the way in simplifying and providing consistency across jurisdictions.

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7 Wastewater treatment upgrade driven by recreational and environmental impacts of a wastewater outfall; A case study from Melbourne, Australia

7.1 Abstract

Water authorities are typically required to monitor the quality of receiving waters near ocean wastewater outfalls as part of recreational water quality guidelines and wastewater licenses. This Chapter presents a review of scientific literature on marine environmental impacts and a discussion of a controversy that developed regarding reports of illnesses experienced by swimmers in the vicinity of a wastewater outfall pipe by presenting media reports of recreational water illness, possible outfall upgrades and ongoing impacts for marine recreators. Scientific literature documents widespread marine environmental impacts, some of which are irreversible. In addition, media reports are discussed which claim that members of the public contracted waterborne illness after swimming near the South East Outfall, a wastewater outfall in Melbourne Australia, and the responsible authority (Melbourne Water (‘MW’)) responded to these. For the purposes of the thesis the significance of this case study is an argued divergence between compliance with state and national water quality guidelines and law, with what some sectors of the community may perceive as environmental performance. This conclusion raises an important area for future research, which is the nature of public statements made by water authorities and the impact these have on recreation behaviour, and public acceptance of the practice of wastewater disposal. For example, do broad statements on the absence of microbial health risks in recreational waters receiving wastewater have the potential to mislead and harm users and in some circumstances may establish a duty of care thereby exposing water authorities to claims of negligence? Secondly, how does communication of recreational risks impact swimming choices and perceptions of water supply options? In jurisdictions where water quality monitoring does not protect users from short term risks, areas for reform in recreational water quality monitoring include more responsive and modern monitoring processes, procedures in the event of very high monitoring results, and clearer guidance on reporting of results.

7.2 Introduction

Policy for management of water quality in receiving waters of ocean outfalls has made a first step in a shift towards more accurate methods that let swimmers know if the water is safe to swim before they enter the water. The United States EPA released updated recreational water quality criteria (US EPA 2012) and the European Commission has undertaken considerable work improving the water quality of their recreational ocean waters through the European Water Framework Directive (Collins et al. 2012, Ramajo-Hernández & del Saz-Salazar 2012). Despite these significant changes driven by research and policy development, parts of the world suffer from poorly performing institutional arrangements for the management of outfalls and receiving recreational waters. Research into the responsiveness of beach users to water quality reports confirms that increasing the accuracy of beach advisories is expected to lead to increased responsiveness (e.g. Kim & Grant 2004, Busch 2009) and deliver considerable economic benefit to beach goers (Pendleton 2008). In contrast, this chapter draws on a subtly different case from Australia as a starting point for identifying possible weaknesses in the communication of environmental and recreational water quality monitoring results, and highlighting opportunities for reform.

Melbourne is Australia's second most populated city with 40 percent of the city's wastewater treated at the Eastern Treatment Plant ('ETP') in Melbourne's east. The remaining 60 percent is treated at the Western Treatment Plant, where some is reused and the remainder discharged into Port Phillip Bay. Wastewater was diverted from the ETP in 1979 to the Bass Strait 56km away via the South East Outfall ('SEO') at Boags Rocks as depicted in Figure 6.1 (Iacovino 2008). The ETP releases a daily average of 350 million litres of wastewater via this shoreline outfall which until 2013 was treated to a secondary standard plus disinfection.

Figure 6.1 shows recreation sites which were impacted by wastewater. These sites are between 2km east and 500m to the west of the SEO. In dry weather there was not predicted to be a significant risk to swimmers and surfers as a result of the SEO (Water Futures 2009). However, under certain conditions there may have been an elevated risk of contracting illness (Hayes et al. 2009, Water Futures 2009). Australian recreational water quality guidelines do not necessarily predict risk outside of 'normal' conditions; exclude children and people with suppressed immunity; and do not consider the health impacts from long-term frequent exposure to wastewater (NHMRC 2008). Part of the discussion of this chapter poses questions as to whether during these times, risks to of public health were accurately represented due to what appears to be an overstatement of the extent of scientific understanding of health risks.

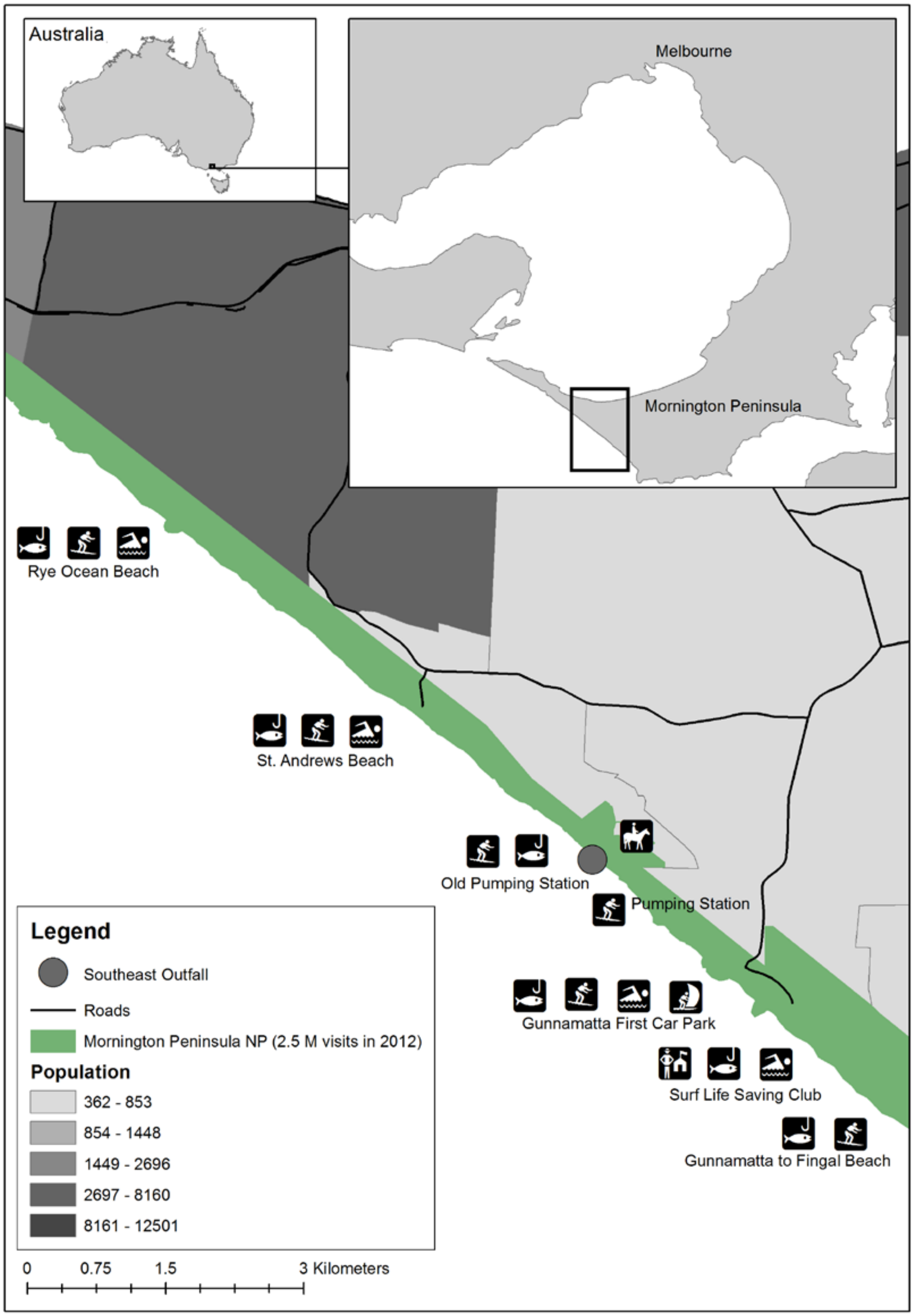

Figure 6.1: SEO, Boags Rocks, Gunnamatta Beach, Victoria, Australia. Adapted from Iacovino (2008)

In 2013 the ETP was upgraded to a high standard of wastewater treatment (Melbourne Water 2013). Two NGOs in particular had an active role in forming public opinion on the SEO, initially the Surfrider Foundation, followed by the Clean Ocean Foundation, formed from concerned local residents. In 1979 the commencement of wastewater discharge at Boags Rocks resulted in an immediate loss of diversity of kelp and algae species at the site (Manning 1979). Some impacts may be permanent (Bellgrove, Clayton & Quinn 1997, Bellgrove et al. 2010). MW acknowledged that the aesthetic impacts of the SEO on surrounding beaches were in a parlous state 'inconsistent with community expectations and policy guidelines'; this included a visible discolored plume, poor water clarity, odour, 'fatballs' from oil and grease, litter including plastic and 'small pieces of sanitary gauze' (Melbourne Water 2009, pp. 87-88).

The remainder of this chapter is set out as follows; Section 6.3 briefly outlines the marine environmental impacts of the SEO. Section 6.4 outlines how the SEO has performed against the Australian recreational water quality guidelines and reviews the studies of human health impacts of the SEO. Section 6.5 discusses public claims of illness made to newspapers and newspaper reporting of MW's responses to these claims. Section 6.6 provides a discussion of the potential impacts of the public communication of water quality monitoring for public health and the ineffectiveness of the regulatory arrangements. The chapter ends with some concluding remarks in section 6.7.

7.3 Marine environmental impacts

Extensive monitoring of the marine environment has been conducted by and on behalf of MW (Molloy et al. 2007, Melbourne Water 2009). Between 2004 and 2007 this included contaminant accumulation studies, inter and sub tidal biological monitoring, aesthetics, water quality monitoring, toxicity and safe dilution assessment (Molloy et al. 2007) as outlined in Table 6.1.

Table 6.1: Studies into marine impact of SEO sewage discharge published in peer reviewed journals

Author	Impact of SEO on marine environment
Brown, Davies & Synnot (1990)	Long term monitoring (1980-1988) records fewer species at sites closest to outfall and those in predominant direction of current H. banksii, C. officinalis, Ralfsia sp no longer at Boags Rocks *B. proboscidea* dominates area surrounding outfall *D. potatorum* (large brown bull kelp) lost from reef edge
Doblin & Clayton (1995)	Secondary treated sewage has deleterious impacts on the early life stages of *H. banksii* and *D. potatorum*
Bellgrove, Clayton & Quinn (1997)	Repopulation of *H. banksii* at Boags Rocks unlikely due to absence and dispersal patterns

	Species that benefit from high nutrient loads have high recruitment and water column propogule density
Hindell & Quinn (2000)	Lower shell growth and higher mortality of Mussel species (*B. rostratus*) at Boags Rocks Lack of *B. rostratus* causes habitat loss for intertidal fauna
Kevekordes & Clayton (2000)	Of heavy metals and salinity effects, *H. banksii* embryos were most sensitive to osmotic stress (low salinity) and ammonium
Kevekordes (2001)	Levels of ammonium in effluent significantly affected development of *H. banksii* embryos after fertilisation Other compounds in SEO wastewater (eg toluene, anionic surfactants) may have similar effects when combined with other impacts (low salinity, competition) and existing stressors
Hogan et al. (2005)	Identifies ammonia as major toxicant in the ETP effluent
Adams et al. (2008)	Observed broad range of toxicity of effluent to species and concluded that ammonia was the major cause of toxicity 1:140 dilution of pre-upgrade effluent required to protect 95% of species from chronic effects (50 per cent confidence)
Bellgrove et al. (2010)	Turf of *C. officinalis* runs south east of SEO replacing *H. banksii* which hinders *H. banksii* from repopulating after upgrade

The most obvious changes from the discharge are recorded on the intertidal reef flat at Boags Rocks where there is now an absence of previously dominant kelp and algae species *Hormosira banksii* (Netptunes necklace), *Corallina officinalis*, *Ulva rigida* and *Gelidium pusillum* (Manning 1979), loss of *Durvillaea potatorum* (bull kelp) at the reef edge (Brown, Davies & Synnot 1990), and reduced shell growth and mortality in the mussel species *Brachidontes rostratus* effects intertidal fauna through habitat reduction (Hindell & Quinn 2000). The intertidal reef flat at Boags Rocks eventually became characterized by deposits of the worm *Boccardia proboscidea* and other species which were favored by artificially higher nutrients (Brown, Davies & Synnot 1990). A similar loss of species diversity continued in a gradient in a south east direction (Brown, Davies & Synnot 1990); turfs of *C. officinalis* have replaced *H. banksii* and this is expected to limit the ability of *H. banksii* to repopulate even if the discharge were to cease (Bellgrove, Clayton & Quinn 1997, Bellgrove et al. 2010). Seafloor flora was found to be reduced in diversity within 660m of the outfall, on the outer reef effects were detected up to 1.4 km from the outfall (Newell et al. 1999).

The level of ammonia within the pre-upgrade effluent was identified as a major cause of effluent toxicity for marine species (Hogan et al. 2005, Adams et al. 2008). Other factors such as salinity and nutrients may continue to impact some species post-upgrade (Adams et al. 2008).

7.4 Recreational water quality guidelines and human health impacts

As described in Chapter 5, NHMRC 2008 guidelines establish two processes for determining bacteriological health risks from primary contact recreation in water. Firstly, a sanitary inspection is carried out which assesses the risks associated with the site and nature of any discharge. Secondly, counts of indicator bacteria are assessed. Numerical values are provided within the guidelines for this assessment but are not enforceable limits (NHMRC 2008).

Wastewater outfalls in Victoria operate under *Environment Protection Act 1970 (Vic)* licences issued by Victoria's Environment Protection Authority (EPA Victoria). The *State Environment Protection Policy Waters of Victoria* 2003 (SEPP (Waters)) establishes water quality standards upon which licences are based. MW monitors compliance with its EPA licence by conducting weekly tests at six shoreline locations surrounding the outfall and monitors a further 13 sites recording *enterococci* and *Escherichia coli (E. coli)* (Melbourne Water 2009).

Table 6.3 summarises the Australian system relative to international arrangements; short term incidents, follow-up procedures and advances in the feasibility of rapid monitoring are areas to be considered for reform. It can be seen that although enterococci is used as the FIB in marine waters in other guidelines, the EPA WWTP relied on *E.Coli.*

Table 6.2: Comparison of ETP EPA licence assessment standards with SEPP (Waters), NHMRC 2008 and USA Recreational Water Guidelines 2012.

	Typical risks over long term	**Enterococci as indicator in marine waters**	**Follow up procedures for high results**	**Rapid methods considered**
EPA Licence	✓	×	×	×
SEPP (Water)	✓	✓	×	×
NHMRC 2008	✓	✓	✓	×
USEPA (2012)	✓	✓	✓	✓

Table 6.3 compares *E. coli* and *enterococci* performance of the SEO for the surf zone, swim zone and discharge point against the limits specified in the EPA licence and SEPP (Water) and as assessed by Sinclair (2001) for the surf and swim zone. For primary contact recreation, the SEPP (Water) requires a 30 day median of no more than 35 *enterococci* organisms per 100ml and 150 *E. coli* per 100ml. No maximum limits are specified in the licence or SEPP (Water), meaning individual high results do not incur a licence breach. Second, licence and SEPP (Water) limits are inconsistently specified or not

specified at all. For example, median *E. coli* is shown as 75th or 90th percentiles and *enterococci* is not included in the EPA licence.

Table 6.3: Comparison of Sinclair (2001) report for samples marked "surf and swimming whole year", EPA Compliance Reporting for ETP discharge monitoring point, EPA licence limits and SEPP (Waters) (Sinclair 2001, EPA Victoria 2003, Melbourne Water 2004, Melbourne Water 2006, Melbourne Water 2007, Iacovino 2008, Melbourne Water 2008)

Indicator	Unit	Sinclair (2001)	03/04	04/05	05/06	06/07	07/08	Licence limit	SEPP (Waters)
E. coli orgs/100ml	Median	0	18	21	16	26	23	200 [a]	150[b]
	90th percentile	15.1	138	70	93	110	118	1000	NS
	Max	190	400	300	3100	610	2500	NS	NS
Enterococci orgs/100ml	Median	0	-	-	10	10	7	NS	35[b]
	90th/75th percentile	2	-	-	89	69	39	NS	150[c]
	Max	84	-	-	320	490	1300	NS	NS

NS – Not specified.

a. Annual median number of organisms per 100ml.

b. Median number of organisms per 100ml based on 5 samples collected in 30 days.

c. 75th percentile of 150 *enterococci* orgs/100ml based on 11 samples collected in 60 days.

Table 6.4 provides a summary of the studies conducted which assessed the human health impacts of the SEO. No studies were located in peer reviewed journals. Three reports were based on results of MW's own microbiological monitoring program. Fairley, Sinclair & Melbourne Water Corporation (1999) compared published studies to MW's measurements of *E. coli*, *enterococci* and Total Coliforms and concluded it was very unlikely that swimmers at Gunnamatta suffered increased health risks as a result of faecal microorganisms.

Table 6.4: Overview of independent studies into health risks from SEO

Report	Methods	Basis for conclusion	Conclusion
Fairley Sinclair & MW (1999)	Desktop assessment	MW monitoring data	No significant risk
Sinclair (2001)	Desktop assessment	MW monitoring data	No significant risk

Water Futures (2009)	Quantitative risk assessment	MW monitoring data, modelling	No significant risk excluding specific conditions
Requena (2009)	Longitudinal cohort study	Surveys of beach users	Recreational water illness detected but no correlation between MW monitoring data and observed rate of illness. Concludes this is likely due to disinfection of FIB
Hayes, Lord & Sherwood (2009)	Review	Independent science group review of MW information	MW monitoring data, modelling and QRA did not account for factors that increase risk and increase shoreline microbiological concentrations

Sinclair (2001) examined MW's microbiological monitoring data (*E. coli, enterococci*, faecal streptococci and faecal coliforms) and compared this to epidemiological literature and guidelines including a draft version of WHO (2003). Sinclair concludes that surfers and swimmers would not be expected to be at a higher risk of adverse health effects as a result of the SEO compared to surrounding beaches. In a 12 month period, 13 days were sampled out of a planned 16 days. Triplicate water samples were taken at 15 locations including at the outfall, in the swim zone, and 800 meters offshore in the surf zone. Sampling was planned to be carried out once a month in the winter months (April – November) and fortnightly in the summer season (December – March). Data for the two indicators in the combined surf and swim zone are presented above in Table 6.3.

Sinclair (2001) is referred to in several MW press statements examined in Section 4 below. Sinclair (2001) lists two uncertainties to her conclusions: 1) an absence of scientific certainty as to whether surfing increases exposure compared to the studies relied upon in the report which focused on swimming; and 2) a lack of scientific certainty on the relationship between levels of indicator organisms and the probability of contracting illness from this particular wastewater.

MW's microbial monitoring program relies on detecting the abundance of *E. coli* and *enterococci* to indicate the presence of other pathogens. Disinfection of secondary treated wastewater (as was the case at the ETP) may destroy faecal indicator organisms to a greater extent than pathogenic organisms which results in underestimates of risk (WHO 2003, NHMRC 2008). As a result, further study is required to determine health risks (NHMRC 2008). In order to meet this, MW commissioned a Quantitative Risk Assessment ('QRA') under the effluent quality at the time and under expected upgrade scenarios and to provide an alternative assessment to account for the fact that NHMRC 2008 guidelines do not account for risk during short term events (Water Futures 2009).

The QRA found that under normal weather and operating conditions the SEO should not pose a significant risk to human health, however during and for a few days after wet weather conditions there *may* be a higher risk (Water Futures 2009). MW's Independent Science Group report questioned the assumptions inherent in the QRA, including the the paucity of testing for worst case scenarios where an interaction of weather, ocean conditions, behaviors such as duration of exposure, and variations in operational conditions could create higher risk situations (Hayes, Lord & Sherwood 2009).

Requena (2009) interviewed 202 beach users at Gunnamatta beach and surrounding beaches and 10 days later checked for the presence of marine related illness. 22 respondents reported a marine related illness. No correlation was observed between illness and the microbiological index indicated from MW's microbiological water quality data. Requena concluded the likely cause of this was removal of indicator organisms and prevalence of other pathogens during disinfection of the effluent. No major health study was carried out to confirm the desktop assessments of disease burden amongst swimmers and surfers and therefore there is no way to validate whether the microbiological monitoring program and QRA (which relied on the microbiological monitoring program) accurately reflects the disease burden. It is therefore possible that the microbiological monitoring program accurately predicted good or very good water quality on average but there remained infrequent and short periods of risk. An example of an infrequent but potentially high risk day is 25 May 2007 where *enterococci* results of 770, 930, 1800, 6, 38 and 14 organisms per 100ml were recorded at each sampling site respectively. During this time MW met SEPP (Waters) limits and licence limits, as displayed in Table 6.3.

7.5 Public claims of recreational water illness

As depicted in Figure 6.1, Gunnamatta is the recreational beach area in close proximity to the SEO and in the predominant direction of the current. This section is intended to provide a historical account of the controversy of this matter. It does not provide a social science or media analysis of what would be a small sample of newspaper articles. The newspaper articles discussed below come from local and statewide newspapers. The accuracy of any illness or environmental impact reported by newspapers cannot be confirmed.

In order to ensure an unbiased portrayal of media coverage searches were conducted on 4 November 2013 on the Australia and New Zealand Reference Centre database for the word "Gunnamatta" across all search fields between 1999 and 2013. This returned 653 newspaper articles in which Gunnamatta was mentioned. Articles were excluded that were not relevant or not referring to specific health or environmental claims leaving 54 remaining. This methodology, and the information in Appendix 1, is provided to assure the reader that an accurate account of the media coverage has been provided.

Of the remaining articles, 32 referred to infections claimed to be contracted from surfing or swimming at Gunnamatta or nearby. As shown in Table 6.5, most articles referred more generally to reports of illness, and some listed outfall associated diseases and included: ear infections, respiratory and dermal problems, viral meningitis, gastric, ear, throat, nasal, respiratory, skin and eye infections and, in three cases, viral meningitis (Titelius 2000, Baker 2001b, Fyfe and Morton 2005, Dowling & Weekes 2006, The Sunday Age 2006, Wilmoth 2006a), gastrointestinal illnesses (Opitz 2012), children contracting sore throats and ear infections (Fyfe 2002a), and ear infections not found at other beaches (Topsfield 2008).

Five newspaper articles named specific individuals who reported contracting disease after swimming at Gunnamatta as summarized in Table 6.5. As the table indicates, a number of individuals had to be hospitalized and contracted life threatening diseases such as meningitis. Individuals were predominantly surfers but also included a lifesaver and a swimmer. Their ages ranged from 17 to 58. A few examples highlight the seriousness of their illnesses: a 22 year old male surfer contracted septicemia requiring an emergency room visit, a week hospitalization with contaminated water mentioned as a possible cause in his outpatient discharge summary (Clifton-Evans 2012); a 47 year old male surfer was admitted to hospital for five weeks with viral meningitis and brachial neuritis taking six months off work; and a 24 year old male spent five days in intensive care after contracting viral pneumonia (Dowling & Weekes 2006).

Table 6.5: Australian newspaper articles between 2000 and 2013 containing reports of human infection claimed to be associated with contacting water close to the SEO.

Sex/Age (y/o)	User type	Reported disease	Newspaper article
Male/22	Surfer	Septicemia requiring hospitalization	Clifton-Evans (2012)
Male/17	Surfer	Impetigo infection (skin)	Fyfe (2010)
Male/19	Lifesaver	Ear infections	Wilmoth (2006a)
Male/(unknown age)	Surfer	Viral meningitis and brachial neuritis	Wilmoth (2006a)
Male/55	Surfer	Infected cut	Wilmoth (2006a)
Male/48	Surfer	Viral meningitis and kidney infection	Dowling & Weekes (2006)
Male/47	Surfer	Viral meningitis and brachial neuritis	Dowling & Weekes (2006)
Female/30	Swimmer	Severe tonsillitis, vomiting, headache, dizziness	Dowling & Weekes (2006)
Male/24	Unknown	Viral pneumonia requiring intensive care	Dowling & Weekes (2006)
Male/(unknown age)	Surfer	Infected cut requiring 6 months antibiotics	Wilmoth (2006c).

In addition to these specific claims, Kellett (2010) describes Requena's (2009) research where 22 marine related illness were reported and, finally, the Director of Surfing Victoria described parent's complaints of sick children after surfing at SEO (Fyfe 2002b). Twenty four of the newspaper articles referred to environmental issues resulting from wastewater disposal at Gunnamatta as outlined in Table 6.6.

Table 6.6: Australian newspaper articles between 2000 and 2013 containing reports of environmental impacts claimed to be associated with discharge of secondary treated wastewater from the the SEO.

Reported environmental impact	Newspaper article
Water issues such as wasted resources	Guerrera (2004), Koutsoukis (2004), Hunt (2006), Mornington Peninsula Leader (2010), Koutsoukis (2006), Black (2002)
Claims a diatom bloom was caused by the outfall	Wilmoth (2006a), Wroe (2006)
Visible plume, brown coloured water and/or odour complaints	Fyfe (2002b), Titelius (2000), Opitz (2012), Duncan (2006), Hagan (2006)
Litter including condoms, sanitary items, cotton buds, and balls of animal fat in the water	Baker (2001b), Miller (2000)
Destruction of marine flora species	Titelius (2001), Hunt (2006), Hudson (2005)
Impact or presence of ammonia	Miller (2000), Titelius (2000), Baker (2001a), Wilmoth (2006a).

In 20 of the newspaper articles MW provided a public statement or response to the claimed health issues. The responses, as outlined in Table 6.7, generally stated that water quality was meeting required standards and is safe, made reference to supporting parts of previous studies, or stated that an upgrade to the outfall was under review. While all these diseases could have been contracted elsewhere, given direct contact by users with the receiving water of the SEO, the possibility that SEO was the source cannot be ruled out. Appendix 1 contains a table where each of these newspaper articles is listed.

Table 6.7: Overview of newspaper reporting of MW statements in response to public claims about alleged public health impacts of SEO

Compliance with EPA licence or requirements

- '…the water was of good quality. It fell within EPA guidelines and there was "a very low risk".' (Fyfe 2002b)
- 'we release treated effluent into the ocean . . . under a strict EPA Victoria licence'. (Clifton-Evans 2012)

• ‘Melbourne Water yesterday defended its discharge practices, saying it met all EPA licence requirements.’ (Guerrera 2004) • ‘Melbourne Water spokesman Ben Pratt said that during the recent algal bloom, enterococci and E.coli levels were within EPA licence limits and those considered safe for recreation.’ (Wilmoth 2006a)
Risk to surfers and swimmers and microbiological health risks • ‘[n]o significant microbiological health risk to swimmers or surfers" at St Andrew and Gunnamatta beaches.’ (Wilmoth 2006b) • The EPA and Melbourne Water insist that surfing and swimming near the pipe - which carries half of Melbourne's treated effluent - is safe. But surfers regularly complain of ear, gastric and eye infections.’ (Fyfe & Morton 2005)
CSIRO 1998 study • ‘Melbourne Water's science and technology manager Peter Scott said a CSIRO study in 1998 showed that the water quality was ``good and met requirements".’ (Titelius 2000) • ‘Melbourne Water managing director Brian Bayley said although CSIRO studies had deemed the water safe for swimming, the authority did not recommend swimming near the outfall.’ (Titelius 2001)
NHMRC 2008 classification • ‘[“]This monitoring shows that water quality consistently achieves good to very good under National Health and Medical Research Council classifications.[“]’ (Kellett 2010) • ‘MELBOURNE Water has given Gunnamatta beach a clean bill of health, saying the water quality has consistently been rated "very good", despite the nearby sewage outfall. After a series of assessments in swimming zones near the outfall at Boags Rocks, Melbourne Water says there's "no significant microbiological health risk to swimmers or surfers" at St Andrew and Gunnamatta beaches.’ (Wilmoth 2006b) • ‘… the monitoring results from the Gunnamatta outfall… consistently showed the water quality was "good" to "very good". (Fyfe 2010)
2001 Monash University report • ‘The statement said a 2001 Monash University report had found no increased risk of illness for surfers or swimmers at Gunnamatta.’ (Fyfe 2010)
High results could be aberrant • ‘But Melbourne Water said the results could be aberrant, as only a thin strip of water appeared to be contaminated, with cleaner water either side.’ (Fyfe & Morton 2005) • ‘…the nature of micro-organisms meant that samples varied day to day and that assessment over time more accurately reflected the beach condition…’ (Wilmoth 2006c)

Furthermore, earlier statements acknowledge beach user concerns; ‘a CSIRO study in 1998 showed that the water quality was ‘good and met requirements’. But the study found that ammonia and fresh water had harmed native seagrass beds which had been taken over by hardier species… Mr Scott said although tests had shown water quality met requirements, he acknowledged that beach users had concerns.’

(Titelius 2000, p. 15). And again a year later MW Managing Director Brian Bayley stated that '… although CSIRO studies had deemed the water safe for swimming, the authority did not recommend swimming near the outfall' (Titelius 2001, p. 22). Following complaints from Surfing Victoria about children getting sick, MW's research and technology manager stated 'the water was of good quality. It fell within EPA guidelines and there was "a very low risk["]'(Fyfe 2002b, p. 9). And further that; '(t)he only way to get to the bottom of surfers' complaints would be a major health study and this would be too difficult and too costly' (Fyfe 2002b, p. 9).

In 2006 a diatom bloom impacted beaches surrounding the outfall (Wilmoth 2006a). This event is associated with nutrient rich waters, which may or may not contain human pathogens, and may result from natural processes such as upwelling currents or rivers, or from man-made factors such as the outfall (Sellner, Doucette & Kirkpatrick 2003). The conclusion of Clean Ocean Foundation that the event was a result of the outfall was not completely unrealistic, given the lack of rivers or other nutrient sources in the region, and summer conditions (onshore winds and low rainfall) which can cause the 'worst case scenario' which was later described by MW's independent science committee (Hayes, Lord & Sherwood 2009). MW stated that 'enterococci and *E. col*i levels were within EPA licence limits and those considered safe for recreation' and the EPA stated 'EPA data showed enterococci levels during the bloom were within safe levels', that it operated within its licence limits, and that no raw sewage was discharged (Wilmoth 2006a, p. 3). No statements from health authorities were identified in this chapter, however, previous chapters have already identified some of the inherent problems within the current regulatory arrangements.

There were also tensions surrounding the public availability of information. With respect to a dispute over releasing data from the microbiological monitoring program;

> …the nature of micro-organisms meant that samples varied day to day and that assessment over time more accurately reflected the beach condition, and they stated that was why; "we have adopted this approach, of not yet releasing the data" (Wilmoth 2006d, p. 8).

Moreover, previously with respect to not notifying surfers of a specific day of high microbiological values, MW was reported as saying results 'could be aberrant, as only a thin strip of water appeared to be contaminated, with cleaner water either side'; the General Manager of Melbourne Water stated that only 2 percent of 3600 samples over five years had been over the limit, and that 'surfing and swimming near the pipe.. is safe' (Fyfe & Morton 2005, p. 11). These statements downplaying the health risks associated with swimming or surfing near the outfall pipe were further exacerbated by the EPA stating that warning people about it was an issue for the Health Department (Fyfe & Morton 2005, p. 11).

7.6 Discussion

7.6.1 General statements may overstate scientific certainty on the possibility of risk

MW's statement that the SEO posed no risk to swimmers is contradicted by three conditions identified by Hayes et al. (2009) where there may be a much greater risk than described in the health studies. Indeed, MW's monitoring program captured several of these days as identified in through the very high maximum levels for *E. coli* and *enterococci* displayed in Table 6.3. MW's statements on the possibility of risk when entering the water are central to the representation of safety at SEO. The NHMRC guidelines in this regard are unequivocal;

> Where specific or extreme events that may threaten public health occur, the relevant public health authority should be informed and recommendations should be made to the water user population about the risks of dangerous water conditions or poor water quality (NHMRC 2008, p32).

Research is required to understand the significance to which people reading local newspapers place on statements that the discharge is compliant with the EPA licence and guidelines represented recreational safety. As previously stated, microbiological monitoring for *E. coli* and *enterococci* has limitations where secondary treated effluent is disinfected because disinfection may cause destruction of indicator organisms at a higher rate than other pathogens (WHO 2003, NHMRC 2008). No studies were undertaken to confirm the ability of these indicator organisms to predict public health risks following the disinfection. In addition, the EPA licence did not specify maximum values for *E. coli* and no limits were specified for *enterococci*; the preferred indicator organism in marine waters (WHO 2003). Choice of bacterial indicators can strongly influence the results of ocean recreational water quality testing (Noble et al. 2003).

Further, Hayes, Lord & Sherwood (2009) recommended that MW's microbiological monitoring program required expansion to account for conditions where shoreline concentrations were increased. MW previously stated that a delay in receiving results made a warning system difficult (Fyfe & Morton 2005); although when events can be predicted, such as after rain, NHMRC (2008) state the need for warnings. In this case, it is argued that regulators should set limits at which action will be taken, such as the Beach Action Values used by US EPA (US EPA 2012). The SEPP (Waters) and licence contain no follow up procedures or notification procedures for when an abnormally high value has been recorded. These monitoring programs reflect long term water quality trends rather than risks from specific incidents or higher risk events (WHO 2003, NHMRC 2008). This distinction is important when public statements about human health are made. Compliance with the licence did not equate to an absence of risk but the two concepts were discussed in conjunction giving this impression.

Secondly, in practice localized user behavioral and environmental aspects may be increasing risk in line with higher risk conditions. For example, surfers at Pumping Stations (a wave break, as noted in Figure 6.1, named for being next to the SEO (Surf Life Saving Australia 2013)) are likely exposed to higher concentrations of wastewater than that represented by samples taken from MW's surf zone. Hayes, Lord & Sherwood (2009) found modelling relied on by MW ignored circumstances where wastewater moved closer to shore and produced higher risk situations; for example during calm conditions, where there are onshore winds, and a south-west swell. Onshore wind and calm conditions could be expected during summer holidays when visitor numbers at Gunnamatta are greatest. Under these conditions higher risk groups such as young children are more likely to swim at this beach using the safe bathing area provided by Surf Life Saving Australia (2013).

The past competence and performance of EPA Victoria's compliance and enforcement has been heavily criticized for being inadequate on a number of grounds prompting a number of reforms (Ombudsman Victoria 2009, Victorian Auditor-General 2010, Krpan 2011). Australian environmental laws often licence and minimise harm as opposed to preventing it. MW's triple bottom line analysis of the upgrade options scored the former treatment capacity of the ETP as the worst of all scenarios considered; stating that it is no longer considered best practice to discharge secondary treated wastewater through a near shore outfall (Melbourne Water 2009). Despite these findings, the practice remained legal under the discharge licence. Interestingly in 2002 the CEO of Melbourne Water published an article which conceded; '[S]horeline discharge of secondary-treated effluent no longer represents best practice, especially near popular beaches', but also noted, '(t)he plant's compliance with its discharge licence has always been impressive with close to 100% compliance being regularly achieved' (Bayley 2002, p. 61).

With respect to environmental impacts there are several conditions found in some US National Pollutant Discharge Elimination Permits which, if included in Australian discharge permits, may serve to demonstrate ecological harm. If harm to ecological communities was strongly discouraged by Australian environmental regulations, compliance with environmental permits may be a better representation of absence of environmental or human impacts. This in turn may have implications when decisions to either upgrade treatment plants or recycle wastewater are made, which is of relevance to this case study. For example, one San Diego permit sates that '[m]arine communities, including vertebrate, invertebrate, and plant species, shall not be degraded', and goes on to provide a range of other protections for marine environmental values including bacterial characteristics (California Regional Water Quality Control Board & US EPA 2009, cl. 4(a)). The permit also requires the exclusion of the 'Initial Dilution Zone' of any wastewater outfall be away from marine communities which are sensitive to wastewater discharges, such as kelp beds (California Regional Water Quality Control Board & US EPA 2009, cl. 1(b)). As noted above, the loss of all bull kelp communities in the area was an almost immediate impact of the SEO.

Another important lesson from this case study is the disparity between recreational risk monitoring in different areas of Australia. The locations in this case study (see Figure 6.1) are less than 15km from Melbourne's Port Phillip Bay beaches. Port Phillip Bay beaches are monitored through the EPA Victoria Beach watch program during summer months (As described in Chapter 5). Whereas Gunnamatta beach is monitored by the Melbourne Water. This means that Port Phillip Bay beaches are subject to microbial trigger values under which action is triggered as soon as a single water quality sample is returned with numbers of FIB over 400 *enterococci* per 100ml (EPA Victoria 2011). Albeit these are informal values not listed in guidelines or legislation, at Gunnamatta beach under State guidelines no action was taken.

Finally, this case study raises the question as to whether the significance of the available scientific reports and evidence was overstated with regard to the certainty to which it indicated recreational swimmer safety. Studies were based on analysis of MW's microbiological monitoring program and they are therefore accurate to the extent that the testing program itself accurately represented water quality during the period of the study. Leaving aside obvious data deficiencies, such as missing months for the monthly water quality testing, ongoing claims as to public health should have been made subject to the limitations of a long term microbiological monitoring program operating in a popular recreational area where disinfected secondary treated wastewater is disposed. This question is important for this thesis because the community is after all reliant on water authorities and regulators to provide them with information on the external impacts of wastewater disposal. Further, the SEO is most likely far more studied with greater monitoring effort than many smaller outfalls in existence. Without clear guidance on communication (such as reporting on NHMRC 2008 compliance) there is a risk that an absence of monitoring effort could be misconceived as an absence of risk.

7.7 Conclusion

There are a number of problem areas in the regulation and performance of ocean outfalls. The upgrade of the wastewater discharged through the SEO demonstrates the process by which Australian water managers respond to the concerns of a section of the community. It was selected as a large and well documented example. However, there are many more small WWTPs discharging to recreation areas and far less monitoring is required for these facilities. The licence and guidelines allowed any level of risk so long as this risk was not seen on a majority of the testing days, hence providing protection but exposing a small number of users to a much higher risk. Public acceptance of this practice may change if lay-people understood what water quality monitoring guidelines do not cover and, that in most cases, they are unlikely to be notified of an above average risk to their health. Reformed guidelines should provide clear and responsive assessment and communication of high risk days, consider local recreational behavior in areas impacted by wastewater, and reconsider the accepted level of risk in the context of evolving technology and community awareness of water quality issues. Of relevance to this thesis, compliance with environmental guidelines in this case study did not align with societal expectations for wastewater treatment. The implications of this for the study for the economics of wastewater reuse are discussed in Chapter 8. Fundamentally, continuing to supply faeces and toxins onto a popular beach location will make people sick, represents a waste of community and coastal assets, and will at some point be remedied through the full extent of the law.[13]

[13] From announcement in 2006 decision making process and upgrade for the ETP took 5 years.

7.8 References

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8 How water quality guidelines allow combined sewage overflows to dispose of untreated effluent: A local comparative case from the antipodes

8.1 Abstract

The ongoing debate regarding water quality in the Tamar River Estuary, which runs through the heart of the city of Launceston Tasmania, is an exemplar of the issues which can arise from a non-binding, non-enforceable Australian national water quality management strategy. This manuscript provides a salient description of water quality management including how water related laws and policy are applied and critically reviews recent reforms to the water and sewage industry which impact the local environment of Launceston. The city has the apparent fame of owning Australia's only large scale Combined Sewer Overflows (CSO); a wastewater treatment system which collects stormwater and wastewater together and overflows untreated water directly to an estuary, lake, river or ocean during moderate to heavy rainfall events. Current water quality management has provided some engineering solutions and increased scientific understanding of the problems this causes. However, Australian water quality guidelines allow the locally degraded nature of the estuary to justify it remaining degraded, continuing to deliver perverse consequences for Launceston's local environment, society and economy. The experience of community groups in the USA reveals lessons transferrable to Tasmania including the need for communication of the location of CSOs, ongoing investment in maintaining infrastructure, enforceable limits and guidelines which reflect modern standards and highlights the importance of community and not-for-profits in informing regulators, and the expected level of environmental protection.

8.2 Introduction

The two largest cities in Tasmania (Australia), Hobart and Launceston, (displayed in Figure 7.1), are both located on estuaries which are highly degraded by historical and current anthropogenic practices (Attard et al. 2011, TEER Program 2012, Derwent Estuary Program 2013, TEER Program 2013a). The city of Launceston sits in the North East of Tasmania where the North and South Esk Rivers all but join to form the upper reaches of the Tamar River Estuary. Launceston's population of 100,000 people have had a considerable impact on the estuary. It is bordered by permanent signage warning against swimming, fishing and drinking the water. Further down the estuary signs warn against consuming shellfish due to heavy metal contamination (Billings 2012, Thompson 2012). All areas of Tasmanian water quality have been impacted by inadequate spending on water and sewage infrastructure (Office of the Tasmanian Economic Regulator 2011b). However, more recently reforms have taken place to create a water and sewage industry operating in accordance with National Water Initiative principles and under a modern regulatory structure (Perraton et al. 2013).

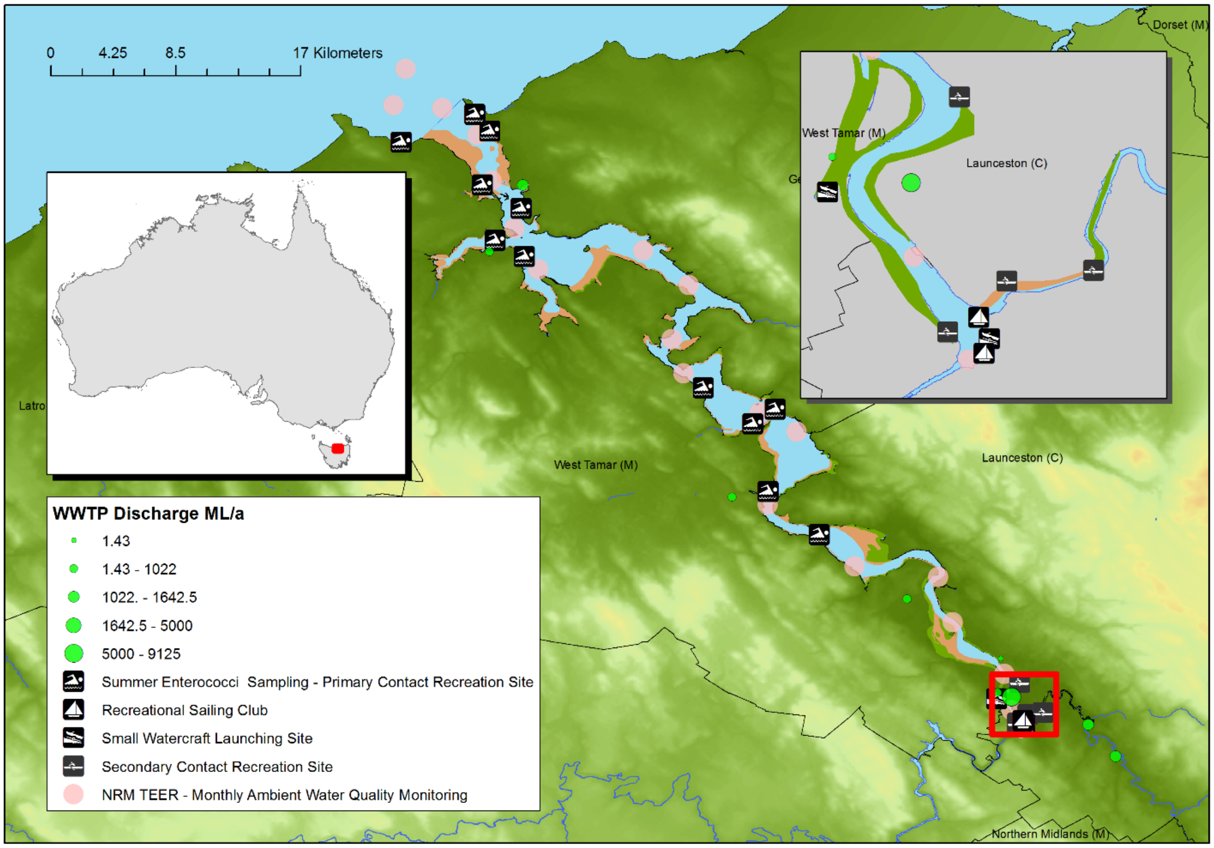

Figure 7.1: Wastewater Treatment Plant (WWTP) discharges, weekly swimming season enterococci testing, monthly ambient water quality monitoring and recreational uses for Tamar estuary, Tasmania.

The 2011 Tamar Estuary and Esk Rivers monitoring report describes exceedances guideline values for faecal bacteria as a historical problem (Attard et al. 2011). In 1994, full reuse investments were made with provision for winter discharges if required to the wastewater treatment plants (WWTPs) which were then operated by West Tamar Council. In 2012, the last WWTP discharging to the estuary on the west bank (Beaconsfield WWTP) was upgraded to full reuse (Ben Lomond Water 2012). None of Launceston's seven WWTPs consistently meet environmental licence conditions and Launceston's combined sewage and stormwater system, the subject of this chapter, places huge pressures on Ti-Tree bend WWTP (TasWater 2014b).

The Tasmanian Economic Regulator labelled long term underinvestment as a cause for Tasmania's water and sewage industry woes (Office of the Tasmanian Economic Regulator 2011b). Today this continues to include Launceston's underperforming WWTPs that regularly discharge untreated wastewater and stormwater through combined wastewater and stormwater overflow points. These discharges impact areas used for primary and secondary contact recreation including junior and adult rowing, sailing, and kayaking and fishing and bathing downriver (e.g. at Swan Bay, Windermere and Hillwood). Signage is erected throughout Launceston at public access points warning against fishing, swimming or drinking this water. It is noted that the water in this location is saline and therefore drinking is unlikely.

Water quality issues have been reported locally and this has led many people to restrict their recreation behaviour. For example, the local yacht club after school program has been impacted (Maloney 2014). Warnings about high levels of cadmium, zinc and copper in shellfish have led to restrictions on consumption (Billings 2012), a sediment dredger (used to deal with sedimentation blocking the river, another water quality issue) became clogged with 'tampon strings' (Martin 2013), and one expert was reported to have said this event indicated the area was unsuitable for any recreation (Andrews 2013). The entity reporting on the health of this river reported the overall state of the upper reaches to be poor, with water quality improving as water moved away from the settlement of Launceston down the roughly 70km estuary (Aquenal Pty Ltd & Department of Environment and Parks Heritage and the Arts 2008). Although water quality improved slightly in later reports, this was due to seasonal fluctuations not to improvements in management (Aquenal Pty Ltd& DEPHA 2008, Attard et al. 2012).

Oysters harvested wild in the Tamar were found to contain levels of metals such as Cadmium, Copper and Zinc that exceeded maximum levels specified in the Food Standards Australian and New Zealand code (Thompson 2012). Above Launceston, at another popular recreation area, Lake Trevallyn, recreation has been impacted by cyanobacteria blooms (Al Qasmi 2013). Dominance of cyanobacteria at certain times of the year in other similar lakes and rivers, may be due to the presence of the varying tolerances to low concentrations of photosynthesis-inhibiting herbicides applied to forestry and agriculture upstream, including the herbicide atrazine (Al Qasmi 2013). This water is also used as a source of drinking water and for recreational fishing, swimming, boating and other aquatic recreation.

The upper reaches of the Tamar estuary have the highest microbiological pollution of the system, with bacterial levels routinely being above guideline values in the upper estuary (Attard et al. 2012). In this area, permanent signage is erected warning against swimming, fishing or drinking water. This is due to contamination by secondary treated wastewater and untreated wastewater (Attard et al. 2012). However, four rowing clubs exist in the upper estuary, a sea scouts, a yacht club and two public boat ramps, which are shown in Figure 7.1. Although testing is inconsistent and not publicised, in 2012 TEER reported a maximum of 4611 *enterococci* per 100ml (Attard et al. 2012).

Furthermore, the Tasmanian Recreational Water Quality Guidelines (2007) do not contain limits for secondary contact recreation and limited monitoring is carried out for these activities. The risk to people practicing secondary contact recreation is unknown because very little monitoring is carried out (Attard et al. 2012) even where, as in the local case of Launceston, untreated wastewater is discharged from CSOs within 100 meters of established rowing, sailing, public boat ramps and a business that hires kayaks to the public. Investment, updated environmental licences, several new plans and other improvements have occurred because of the absence of secondary contact limits and indigent monitoring across Tasmania. In the case of water quality, the most significant of these plans are the Compliance Implementation Plans (Tasmanian Government Department of Primary Industries Parks Water and Environment (DPIPWE) 2009), which formed an inferior bridge between where regulators would like to see improvement and the paralysis caused by financial restrictions and existing political tensions (Perraton et al. 2013).

8.3 Roles, responsibility and commitment to policies

8.3.1 The Interviews

In order to understand and document the roles, responsibility and commitment to policies of various institutions within recreational water quality management in Tasmania and the USA, the first mentioned author undertook a series of interviews with representative officers. Interviews were conducted across the period from January 2014, to April 2014 with officers of Tasmania's state health regulator, local government environmental health departments, the state economic regulator, the Tasmanian water corporation, TasWater, and an NGO in the USA. Questions asked were general in nature relating to procedural matters specific to each area of responsibility for each interviewee, for example, the timing and location of recreational water quality testing or the procedures for reporting health risks. Appendix 2 provides a more detailed explanation of the methods used to conduct the interviews.

8.3.2 Tasmanian recreational water quality monitoring practices, roles and responsibilities

Recreational water quality testing in Tasmania focusses on popular swimming areas during summer months (Tasmanian Government Department of Health & Human Services (DHHS) 2012). The guidelines recognise that it is impractical to regularly monitor all waters used for recreation, however they state the need for controlling authorities to monitor popular areas and where there are identified sources of pollution which risk human health (DHHS 2007). Testing is not carried out specific to point source discharges (DHHS 2014).

Tasmania's Recreational Water Quality Guidelines (DHHS 2007) pre-date the National Health Medical Research Council 2008 (NHMRC 2008) guidelines. In summary, they require weekly water quality monitoring during the swimming season. When a result is returned for a single sample greater than 140 *enterococci* organisms per 100ml, another sample must be conducted within 48 hours and conduct a sanitary inspection to determine possible causes of elevated results. When two consecutive results are returned with over 280 *enterococci* organisms per 100ml, the public should be notified and signage should be erected (DHHS 2007). Section 184 of the *Public Health Act 1997 (Tas)* requires compliance with the guidelines and there is a penalty for non-compliance. As noted above, the guidelines apply to primary contact recreation only and not secondary contact.

Testing for water quality is performed by local governments for recreational water quality, and general catchment water quality monitoring is carried out by the Tamar Estuary and Esks Rivers Program (TEER) (TEER Program 2013a). In the swimming locations (Figure 7.1) tests are conducted weekly by local government Environmental Health Officers ('EHO') with three local governments having responsibility for conducting water quality testing in this area (DHHS 2012, Launceston City Council 2013, West Tamar Council 2013). The West Tamar Council Environmental Health Officer ('EHO') undertakes weekly sampling at 8 locations associated with primary contact recreation (West Tamar Council 2013). George Town Council collects samples at four locations (DHHS 2012), and Launceston City Council collects samples at four locations (Launceston City Council 2013, West Tamar Council 2013). No recreational water testing is performed in the upper Tamar estuary area displayed in Figure 7.1.

Tasmanian local governments would ordinarily have responsibility for both stormwater management and recreational water quality, however Launceston's stormwater is collected through the combined system operated by TasWater. Launceston City Council is a shareholder of TasWater. While TasWater operates the CSO and its infrastructure, TasWater does not monitor the receiving waters for human health and safety.

In the case of sewage spills TasWater has notification responsibilities under Section 32 of the *Environmental Management and Pollution Control Act 1994* (Tas) for environmental harm. Further, Section 128 of the *Public Health Act 1997* (Tas) requires TasWater to tell the Director of Public Health if it becomes aware of waters within its management a risk to public health. This means that if a sewage spill occurs, TasWater notify the local government EHO who are required under the *Public Health Act*

1997 (Tas) to take action which in practice may include public notification, sanitary surveys and informing the Department of Health and Human Services (DHHS). Most importantly, interviews showed that in the case of discharge from a CSO, sanitary surveys and notifying the Department would not occur.

When a sewage pumping station spill occurs, Tasmanian guidelines for sewer overflows from pumping stations would ordinarily require notification of authorities who would in turn put in place public notifications if necessary. As mentioned this does not occur with Launceston, the Sewage Pumping Station Environmental Guidelines guidelines do however address Launceston specifically in stating;

> With combined systems, every effort should be made to identify environmentally sensitive areas, and public access areas, and develop and implement the necessary management plans to minimise impacts and/or to notify key users of the public of events which might impact on their use or safety.
>
> System upgrades should occur with due regard to investment expense and the continuous improvement of water quality outputs, taking into account the advantages of treating both sewage and contaminated stormwater (Tasmanian Government Department of Primary Industries, Water and Environment, 1999, p. 23).

The NWQMS addresses sewer overflows in the Guidelines for Sewerage System Overflows (2004) which states;

> As soon as practicable after the overflow has been detected and the level of risk presented by the overflow has been estimates, the sewerage system operator notifies relevant stakeholders. These may include:
>
> - environmental and human health agencies;
> - local councils;
> - waterway mangers;
> - downstream users potentially affected by the overflow; and
> - the media for public notification of large events (Natural Resource Management Ministerial Council 2004, p. 32).

In order to access the information on water quality in the Tamar and surrounding regions, a person would need to contact one of five authorities, depending on where the site was. This makes the task of protecting oneself insidiously difficult. Central sites are permanently closed for swimming, but full body immersion may occur during these times at organised rowing and children’s sailing events and during other less formal aquatic pursuits such as kayaking. The Department of Health produce an annual summary of recreational water quality for the State of Tasmania (e.g. DHHS (2012)).

8.3.3 Water quality – Tamar Estuary and Esk Rivers (TEER)

TEER is a regional partnership which focuses on water quality issues on the Tamar Estuary, and the South Esk and North Esk Rivers. It is made up of a committee of the members, a scientific group and issue specific groups. Launceston City Council, West Tamar Council, George Town Council, Northern Midlands Council, Meander Valley Council, TasWater and Hyrdro Tasmania are the TEER partners. TEER's area of operation is very large because it incorporates large catchments in the Northern half of Tasmania as well as the estuary. However, recreational water quality monitoring is not a key priority of this program. The focus of TEER is primarily ambient water quality monitoring and providing science to guide decision making, not monitoring for recreational quality on a day to day basis (TEER Program 2013).

Prior to TEER's formation there was a gap in responsibility for water quality and catchment management on the Tamar Estuary and North and South Esk Rivers. The Parliament of Tasmania Legislative Council Select Committee into the Management of the Tamar Estuary and Esk Rivers recommended that a statutory authority with State Government funding was required to properly manage the area (Parliament of Tasmania 2008). This recommendation clearly did not match the will of the relevant local governments and agencies who showed a lack of willingness to take responsibility, reflecting a typical problem with open access resources described by lawyers and economists as a tragedy of the commons (Hardin 1968), or by game theorists as prisoner's dilemma (Kuhn & Tucker 1950).

Despite lack of statutory authority and arguably lack of enforcement penalties, there are some advantages to having a voluntary regional partnership model run by an independent not-for-profit organization. The TEER has had some success because it allows communication between all the members in a forum under which they make decisions and share knowledge (TEER Program 2014). Further, without TEER there would currently be no organization responsible for the work it carries out.

The Water Quality Objectives (WQOs) are values which can be set under the SPWQM which indicate what must be achieved for Protected Environmental Values to be upheld. In 2008 the Tasmanian Government initiated a review of the SPWQM because of problems including lack of WQOs and Protected Environmental Values in many catchments and in coastal waters across Tasmania, as well as the SPWQM being out of date with national water quality guidelines (Tasmanian Government

Department of Environment Parks Heritage and the Arts 2008). WQOs are not set for the Tamar estuary and therefore default back to national objectives for ambient water quality, the Australia and New Zealand Environment and Conservation Council 2001 guidelines and water quality objectives (Gunawardana & Locatelli 2008). To address this TEER is developing a Water Quality Improvement Plan (WQIP) to enable sound scientific understanding of a model of water quality, further enabling partner organisations to assess options for planning and investment given the environmental and economic benefits that they provide (TEER Program 2013b). Relevant to the CSO, the WQIP will be impacted by TasWater's development of a "Launceston Sewerage Improvement Program" (TasWater 2014c). Both programs involve public consultation.

8.3.4 The Office of Tasmanian Economic Regulator

Under the *Water and Sewage Industry Act 2008* (Tas) Section 12, the Office of the Economic Regulator has the power to regulate prices and funding allocations for projects as well as responsibility for monitoring the performance of TasWater, including environmental performance. Investment in improvements to infrastructure which improve water quality rely on Price and Service Plans (PSPs) which in turn are set by the Office of the Economic Regulator. These plans require balancing of societal preferences such as price concerns with needs of regulators such as drinking water quality and the need to overcome environmental damage from wastewater treatment plants (Ben Lomond Water 2011, Southern Water 2011, TasWater 2014a). The Economic Regulator has a role in coordinating other regulators to ensure TasWater can financially meet targets set in compliance implementation plans with which focus on improving water infrastructure.

Another priority of the PSP is dealing with residual issues of differences in what people in different areas pay for water and sewerage the economic regulator (TasWater 2014a); this impacts spending on water quality improvements because the economic regulator has to keep the corporation below revenue limits defined by national policy and Tasmanian law (Office of the Tasmanian Economic Regulator 2011a).

If the strategy chosen to deal with Launceston's WWTPs following TasWater's "Launceston Sewerage Improvement Program" (TasWater 2014c) is reuse, another set of revenue and regulatory intricacies will emerge. Although the Wastewater Reuse Coordinating Group will assess this proposal (As described in Chapters 3 and 4), it is known from the interview that the economic regulator will retain a role of ensuring due diligence and expects a business case for a scheme.

One reason for this is because it is in the interest of monopoly businesses to invest as much as possible in, what is referred to in the industry as, 'gold plating' assets and charge users a higher return of and return on assets if allowed. With respect to capital expenditure, Tasmania has taken what is known as a "line in the sand" approach. This means that assets purchased by previous managers and transferred to TasWater should earn a lower rate of return than new assets which earn a commercial rate of return (Southern Water 2011).

Another complication is that although the dual stormwater and sewerage system collects wastewater and therefore TasWater charges customers for this, as a stormwater collection system, this becomes an "unregulated asset". This means TasWater is required to re-coup the costs and return on this asset from Launceston City Council; who are part owner of TasWater (Office of the Tasmanian Economic Regulator 2011a).

8.3.5 Lack of transparency or regulatory uncertainty

As depicted in Table 7.1, Roberts and Craig (2014) discuss regulatory uncertainty under four categories of: (1) objectives, (2) clarity of objectives and legal interpretation, (3) clarity of institutional responsibilities, and (4) enforcement capacity.

Table 7.1: Issues for transparency and accountability within Tasmanian water quality management under State Policy on Water Quality Management 1997 (Tas)

(1) Objectives	To focus water quality management on achieving water quality objectives which will further the State's resource and planning objectives.
(2) Clarity of legal interpretation	Tasmania's SPWQM uses broad aspirational language describing conditions for disposal to surface waters including accepted modern technology, best practice environmental management, protected environmental value (where these have not actually been set), and technology based criteria or standards.
(3) Clarity of institutional responsibilities	SPWQM lists NHMRC guidelines as applicable for human health unless specified by the Director of Public Health and lists the Board of Environmental Management and Pollution Control as responsible for other guidelines. In practice statutory duties for water quality management in the Tamar and its catchment are dispersed between various government entities brought together voluntarily under TEER. Wastewater reuse assessment performed by informal grouping of relevant department members under WRCG. Both TEER and WRCG non statutory bodies.
(4) Strength of enforcement powers	Little to no capacity for enforcement or repercussions for government authorities if the TEER finds SPWQM objectives not met; by comparison water authority goals such as revenue to shareholders are made through enforceable legal instruments. Enforcement mechanisms are for general environmental harm (EMPC Act), conditions in wastewater discharge licences, and conditions in recycled water approvals and agreements. Funding uncertainty and cuts for water quality monitoring (TEER Program 2013) may add to this.

Factors which might impact regulatory effectiveness of water quality management in Tasmania include water quality guidelines which are aspirational and have no or limited enforcement mechanisms. These soft mechanisms ignore the need for accountability of government institutions in meeting their regulatory duties as well as provide a lack of clarity surrounding responsibility and targets (Roberts and Craig 2014). When considering aspirational government policies and targets, local governments and water authorities balance competing priorities for expenditure resulting in unjust outcomes for local people. This is reflected in the discussion above of the role of the Economic Regulator in approving price plans.

A 2008 Tasmanian Government review of the SPWQM identified problems with implementation of the policy including lack of WQOs and Protected Environmental Values (PEVs) across the State's inland and coastal waters as well as it not reflecting changes to national water quality strategies (Tasmanian Government Department of Environment Parks Heritage and the Arts 2008). The SPWQM provides a list of PEVs which can then be selected to apply to particular surface waters. PEVs are values to be maintained, for example, primary contact recreation or drinking water. As discussed above, these are not yet set for some Tasmanian waters.

However unlike Victoria's SEPP (Waters) policy which provides numerical limits for water quality indicators as to what some waterbody types should ideally look like, the SPWQM does not. The use of terms like 'best practice environmental management' or 'accepted modern technology' necessitates that some level of minimum standard be established either in the policy or in supporting guidelines. Some values are provided in further guidelines such as: 1) some uses of recycled water are covered by the Environmental Guidelines for the use of Recycled Water in Tasmania (Tasmanian Government Department of Primary Industries Water and Environment 2002), 2) Tasmanian Recreational Water Quality Guidelines (DHHS 2007) provide limits for primary contact recreation which are less protective than NHMRC 2008, and 3) emission limit guidelines for WWTPs discharging less than 500 kilolitres a day average dry weather flow (Tasmanian Government Department of Primary Industries Water and Environment 2001).

These guidelines do not cover all SPWQM PEVs; of particular relevance to the CSO, there are no limits set for secondary contact recreation. Clause 8.2 SPWQM states that where there are no Tasmanian guidelines, national guidelines apply. However, in practice, despite established use of the Tamar estuary being a secondary contact area, as well its status as a PEV, there are no microbiological monitoring or reporting for secondary contact recreation safety in the Tamar estuary, with the exception of any samples taken within the ambient monitoring conducted by the TEER.

8.4 Regulation of CSOs in USA

Under the US *Clean Water Act* (CWA), discharges to water are required to have a National Pollutant Discharge Elimination System (NPDES) permit. However for CSOs in the USA, the EPA regulates their design and monitoring with guidelines (US EPA 1999). These do not create rights enforceable in litigation. They are applied by states or in setting permits. These are then applied in the permits. This is an important distinction because it creates a point of weakness where the permit may not require public notification. This has led to criticisms from lobby groups who proposed laws for signage and notification for CSOs, as well as better urban design to minimise impacts (Plumb 2006).

CSOs in the USA will be considered a point source discharge as part of a sewage treatment system that possesses a NPDES permit. Ordinarily this means that CWA technology and water quality based standards apply. However, the US EPA has stated that for the 9,348 CSOs operating under 828 NPDES permits (US EPA 2004), the CSO itself will be exempted from requirement for secondary treatment (US EPA 2001). The US EPA issued a Combined Sewer Overflow (CSO) Control Policy (US EPA 1994). This followed a 1989 policy which dealt with identifying CSOs and commencing permitting and moving to minimise impacts. Although this policy is based on bringing CSOs and their NPDES permits to meet CWA requirements, its language is still based around flexibility and phasing changes in allowing for financial capacity in various locations (US EPA 2001). Two aspects of the policy were nine minimum controls to be incorporated in NPDES permit which did not require substantial investment in infrastructure, and for Long Term Control Plans (LTCPs) to be developed. Although the policy had a deadline for implementing these by the time this deadline arrived only 52 percent had started implementing the nine minimum controls and 33 percent had implemented long term control plans (LTCPs) (US EPA 1998). By 2004 the number of LTCPs had increased to 59 percent (US EPA 2004). Of course, since this time the US EPA has issued a range of guidelines and various States have included parts of the controls and plans in some form of enforceable mechanism.

The nine minimum control measures are: 1) maintaining and operating the CSO and sewer system properly, 2) maximising storage, 3) ensuring CSO impacts are minimised by requirements for pre-treatment, 4) maximisng the flow that goes to the WWTP (Publically Owned Treatment Works POTW), 5) no CSO discharge during dry weather, 6) solid and floating materials should be controlled, 7) using pollution prevention to reduce contaminants, 8) public notification for CSO occurrences and impacts, and 9) monitoring CSO impacts and how well controls are working (US EPA 1995). Where CSO and SSO impacts occur during wet weather the US EPA has stated a preference for whole of catchment approaches (US EPA 2001). Therefore in addition to the 9 minimum controls, CSOs should have LTCPs developed.

One NGO that objected to aspects of the implementation of the US EPA policy on CSOs was the New Jersey Baykeeper, who supported a bill to increase communication of CSO discharges (NY/NJ Baykeeper 2013). *New Jersey Assembly Bill 2852 (NJ USA)* was a bill that would have required an entity operating a CSO to report when a CSO discharged raw sewage to a waterway. Breach of the notification requirements would result in a breach of the CSO's NPDES permit. The Legislative Fiscal Estimate states that there are approximately 200 CSOs owned by 40 local governments which would require notification under this requirement (New Jersey Office of Legislative Services 2013).

Furthermore, CSOs discharge into surface waters, but it is not readily known or advertised how much rain will result in a spill because this is impacted by many factors. These factors can be seen in an EPA guidance which has been incorporated into the CWA concept of minimum best technology, which includes cleaning pipes, maximizing treatment and giving notice of discharges. As noted from the New Jersey Baykeeper interview, despite the CWA making it illegal to discharge to waters without a permit, these requirements are often not in the permits themselves. In this latter case, citizens or not-for-profit groups may sue under the CWA. By contrast, this right does not exist in Australia. There are some rights to interact with proposals under legislation.

From the interview, it is known that New Jersey Baykeeper believes there were costs to society from having people not know the quality of the water, often which may not be known to the regulator. For example, economically disadvantaged people living and relying on the river water can be particularly vulnerable. Moreover, the costs of additional signage would be justified by the outcome of letting people know about their safety and the public would expect that such basic information on system performance would be known to those responsible for its management. In addition, at the very least and from an ethical perspective, managers have a duty of care to know the capacity of their system to the extent that they can predict with some certainty when they will discharge untreated sewage. However, what we see in Australia is an ability of managers to avoid their duty of care and in such a situation, providing the public with the right to sue would be preferable. In contrast, in the USA, violations under CWA can be pursued as a law suit under this Act which according to New Jersey Baykeeper is a well-known course of action for concerned community members and groups.

In other US jurisdictions more progress on CSOs has been made. For example, in Michigan laws exist requiring reporting of all CSO discharges including volume, quality, corrective actions and other aspects. In addition, authorities are required to produce an annual report which includes progress towards stopping CSOs and barriers encountered (Michigan Department of Environmental Quality 2013). Further, in Chicago the US EPA ordered that water quality standards for Chicago's lakes, rivers and canals be updated to allow for what is called secondary contact recreation in Australia. This order necessitated wastewater facilities to be upgraded to disinfect wastewater before it is discharged (US EPA 2011). Although the Chicago decision relates to wastewater treatment as opposed to CSOs, it does represent the recognition of the value of waterways for secondary contact recreation.

8.5 Discussion

*8.5.1 **Lessons from USA CSO regulation for Australia***

Australia has one true CSO in Launceston but also many SSOs on the east coast that discharge during extreme weather. In many other jurisdictions, such as California in the USA, a sewer spill would result in closure of the affected recreational area until bacterial monitoring can show there is no risk to health (California Environmental Protection Agency 2015). Absurdly, it is unclear why Tasmanian environmental law requires the public to be warned when there is an accidental or unplanned sewage spill but not when untreated sewage is discharged from a CSO. Meaning that warnings are based on the infrastructure causing the spill even though there is equal risk to the public.

With respect to regulatory uncertainty, when conditions are included in individual permits there is a reliance on updating of the permit in order that modern standards are upheld. If one were to compare Australian water quality guidelines to one part of US EPA guidelines you may find close similarities between all Australian guidelines and the US CSO guidelines; they are both not enforceable, they both have had challenges in implementation.

Non-enforceable guidelines can potentially become a yardstick where states then judge their performance and upon which the community and TEER can apply pressure (Ward, Buller & Lowe 1996). However, firstly in application, Australia's water quality management provides almost no rights for the public to litigate or participate except in limited circumstances during when the permit or licence is being drafted. Australia relies largely on enforceable permits agreed to between polluters and regulators. Secondly, Australian water quality guidelines are all guideline-based like the US CSO guidelines compared to other areas of water quality more heavily regulated by US EPA under the CWA. This means that the point of weakness in the Australian case is where the individual state regulator is required to apply the largely aspirational state guidelines under a wide variety of processes and political environments. The contrasting roles of research input of the TEER in Tasmania, and the advocacy role of the NJ Baykeeper in the USA, both demonstrate that Australian and US environmental legislation for CSOs relies upon community and research input in order that permits are set at levels informed by societal expectations for water quality;

this in turn demonstrates the pitfalls in relying on enforceable limits which are only contained in individual permits negotiated on a case by case basis primarily between regulators and polluters; and therefore outside the view of community and interest groups.

8.5.2 Effectiveness of management

There may be a range of reasons why the Tasmanian State Government did not follow the Tasmanian Parliamentary enquiry's (House of Assembly Select Committee into the Tasmanian Water and Sewage Corporations 2012) recommendations for the TEER to be a statutory body. Two reasons may be that, with the power structures of existing agencies, a loose regulatory arrangement may suit some bodies, and other financial pressures in Tasmania may have taken precedence for spending. The TEER and the Tasmanian Economic Regulator both provide informal forums for various bodies to meet under one roof and it could be argued this may not happen if the TEER was a regulatory body. Does this cooperative role outweigh the potential for an ethical dilemma caused by the TEER being effectively the champion for a river that is polluted by the groups who fund TEER? The impact of this dilemma on the effectiveness of any catchment management body's ability to conduct its business requires careful consideration.

Moreover, while the Tasmanian DHHS has statutory responsibility for recreational water quality safety in practice, monitoring is carried out by local government officers with DHHS intervening during high risk events. Programs such as NSW Beachwatch utilize a more active model of cooperation where the State government department assists councils, the public benefit through consistent reporting, greater commitment from state government in training council officers where councils are unable to provide themselves, and the state benefits from having areas outside of its capacity monitored (NSW Government Department of Environment and Heritage 2014).

If the focus of recreational water quality monitoring in Tasmania is not on point source discharges where sewage is discharged, and instead based on where people swim and therefore exposure to risk, this thesis argues that there should at least be a statutory responsibility to appropriately warn people of areas where sewage is discharged. Logically, from the perspective of protecting public health there should be no difference in the treatment of a one-off sewage breach and a more pronounced event that occurs more frequently. As highlighted above, the control of information by parties managing infrastructure and inability for the public to access any information on when and where a discharge occurs removes the ability for people to make informed decisions. There also appears to be no justification for the absence of protection for secondary recreation users in Tasmania.

8.5.3 Comments on overall success of governance

The establishment of the TEER is a positive step because previously very little data was collected. However, because secondary contact is absent from recreational water quality management in Tasmania, simultaneous occurrence of very poor water quality in the upper reaches of the Tamar and the high levels of secondary contact recreation, especially for children, provides for a highly unpalatable and unjust local outcome. The second area that is absent in the recreational water quality management framework is that of polluter responsibility for monitoring receiving waters. Tasmanian Councils have responsibility for monitoring wastewater but limited responsibility in other related areas. Additionally, there are knowledge gaps for risk assessment including recreational user behaviour, the composition and dilution of wastewater, and the quantity and frequency that untreated sewage is discharged from overflow points.

This case study demonstrates circularity consistent with non-binding Australian guidelines; the Tamar Estuary is a degraded system due to current and historical management, as a result it lacks beneficial uses such as swimming, therefore these are not included in water management objectives, and therefore today the estuary continues to be degraded; reinforcing current malpractice to continue. Even if there was microbiological monitoring, to degrade water where people swim by discharging sewage and then expect water monitoring to manage this risk represents a backward way of managing risk. Instead, by managing human waste correctly and providing proper warnings for stormwater and other events, the risk of illness can be minimized.

That said, some risks, such as having children’s rowing events in water contaminated by untreated effluent, are unmanageable under current Tasmanian recreational water quality management structure; the users are outside the guidelines, and management efforts do not address the risk. Instead for example, clubs could be approached in order to identify the days and times when most secondary contact users are likely to be on the water and risk assessment (using the risk assessment matrix developed by Healthy Waterplay, Queensland, described in Chapter 5) could be undertaken around the most vulnerable users, enabling water quality decisions prior to junior rowing events.

The approach described in the USA was a guideline based approach. That is, rather than having CSO limits within the CWA they are within the CSO Control Policy and associated guidelines. Both the US CSO Control Policy and Australian water quality guidelines do not provide rights enforceable by citizens through litigation. Australian water quality guidelines are non-enforceable. They are implemented at the State level through guidelines which are often aspirational with the bulk of enforceable standards being contained in licences agreed to by regulators for specific facilities. There are very limited rights for the public to participate in these licences and few rights enforceable by citizens through litigation.

The state of the Tamar estuary is indicative of how Australian water management focuses on finding solutions within a pre-determined paradigm where disposal to water is the primary choice against which other options are compared, to the exclusion of alternative uses and possible benefits such as tourism which if allowed can contribute to the understanding of the economic and intrinsic value of water (Bruzzi et al. 2011) or alternative technologies which completely shift paradigms of wastewater treatment (Teh 2013).

The absence of water scarcity in Tasmania and the degraded nature of many waters due to current and historical practices may be a factor which has prevented advancement of watershed management and urban design. Despite the difficulties with fixing CSO problems, like high costs, the guidance and nine minimum control measures used by the US EPA should be considered by Tasmanian regulators. In particular, emphasis on pollution prevention programs, watershed management and water sensitive urban design, public notification given presence of secondary contact recreation near CSOs, and monitoring and characterizing of the impacts of CSOs should be considered by water reformers.

8.6 Conclusion

The challenges faced by TasWater, and the economic and water regulators in updating Tasmania's urban water infrastructure while balancing budgetary and political pressures demonstrate the pitfalls of not meeting the first of the USA EPA's nine minimum controls, that is, to maintain infrastructure. Despite recent progress, there are obvious shortfalls in the management of the Tamar estuary and the North and South Esk Rivers that flow into it. Launceston's outdated wastewater system and its CSOs are one example of this. Four other water quality management challenges which operate to provide negative pressure against calls to reduce impacts of CSOs: 1) the absence of protection of secondary contact recreation, 2) competing spending priorities, 3) the lack of transparency in processes, 4) and regulatory uncertainty within water quality guidelines. Combined, these factors and Launceston's CSOs present significant barriers for TasWater and other regulators to remedy a situation which is permissible under non-enforceable national water quality guidelines and the ability of State and local governments to hide behind the excoriating veil of water corporations to avoid necessary and essential spending on infrastructure. Immediate priorities should be to reform water quality guidelines and environmental laws so that human health and environmental impacts are not allowed to be considered secondary to profit requirements, and to focus on reducing local urban runoff through planning.

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9 Conclusions, implications and discussion

9.1 Introduction

This chapter draws on previous chapters to highlight aspects of urban water governance and water quality management which may support wastewater reuse. A summary of the thesis is followed by a discussion of key policy implications, synthesizing the constituent parts of each chapter of the thesis. The hypothesis of this thesis was that the '*management of the external impacts of wastewater disposal in Australia is currently not optimal and this creates a barrier to wastewater reuse and extends to broader consequences for the marine and coastal environment'*. In order to address this, this thesis put forward a multidisciplinary analysis of case studies from Australia, supported by case studies from the USA, to provide international perspectives. In doing so, it has identified areas for reform in environmental management, as well as identifying new barriers to wastewater reuse for future investigation.

The opening chapters of this thesis identified potential barriers to wastewater reuse in urban water governance structures and processes, providing a case study of recent reforms of the water and sewage industry, driven by poor environmental performance and underinvestment. The case studies were selected as examples to showcase distinct elements of water governance structures and environmental guidelines. The broad discussion of environmental regulation and barriers to wastewater reuse of the opening chapters was followed by a detailed description of recreational water management with two case studies of treated and untreated wastewater disposal into recreation areas demonstrating specific aspects of environmental regulation are deficient. This was achieved through management and communication of recreational water in Chapter 5, and management of recreation in wastewater discharge areas in Chapters 6 and 7. Together the chapters allow recommendations for reform to be made.

The remainder of this chapter is set out as follows; Section 8.2 is a summary of the thesis, providing highlights and a summary of each chapter. Section 8.3 provides a discussion of the key findings of this thesis. It divides these into three broad themes allowing the broad nature of the topics in the thesis to be synthesised: 1) inadequacies in management of discharged wastewater; 2) water industry governance structures which may divert capital away from investment in water quality improvements; and 3) 'coalescing concealment' of transparent feasibility assessment. Section 8.4 provides general comments, allowing for broader discussion of the barriers previously discussed. Section 8.5 presents the limitations of the thesis. Finally, Section 8.6 closes the thesis with some brief concluding comments.

9.2 Summary of thesis

Each chapter of this thesis described different and sometimes overlapping systemic elements of water management and governance which may influence wastewater reuse assessment in favour of environmental disposal. Chapter 2 described Australian water quality policies and the regulatory framework for managing environmental pollution and recreational water, and briefly overviewed intergovernmental agreements for national water reform. This chapter described wastewater disposal laws and policies in each Australian state focusing on licensing, mixing zones and recreational water quality management. Three aspects of national environmental protection were described; the NWI, NEPMs and the NWQMS. These national policies came about through intergovernmental agreements between the states and territories and the Commonwealth Government. This is relevant to the subsequent chapters because it demonstrates how the Australian constitution gives states power to make laws over water quality control and management, and every Australian jurisdiction approaches urban wastewater management differently. It also demonstrates the mechanisms used to provide consistency between jurisdictions for water matters. Notably the NWQMS for which NHMRC 2008 recreational guidelines belong is not supported with legislation in the same manner as the NEPM policies described.

The second section of Chapter 2 describes wastewater disposal regulation, guidelines and practice. Notably this legislation is set by each state government and criteria for water quality in receiving waters are incorporated into WWTP licences. Barriers to wastewater reuse are discussed in Chapter 2 under themes of; 1) institutional and governance arrangements; 2) difficulties in determining the true cost of disposal options; 3) economic issues of competition and demand for water sources; 4) water quality management, for which the balance on the literature focuses on recycled water as opposed to environmental waters; 5) political influence on decision making which has led to selection of other projects over recycled water; and 6) perceptions of recycled water.

Chapter 3 provides an example of a wastewater reuse scheme, which came about following intense reforms of Tasmania’s water and sewerage industry and led the environmental regulator to reform a large number of wastewater discharge permits, requiring wastewater reuse feasibility to be studied before ongoing discharge was allowed. This situation allowed for discussion of the economic regulation of water and sewage industry, the pressures of competing priorities, both financial and political, and postulation of the impact on wastewater reuse. Perhaps controversially, within this chapter it was argued that given evidence of reasonably severe human health risks due to outdated infrastructure, the operation of a profitable water industry was not an appropriate paradigm.

Because of the diverse array of water management regimes in Australia, the thesis returns to Tasmania in Chapters 3, 4 and 7 where one of the environmental impacts of underperforming wastewater infrastructure (identified in earlier chapters) is examined in the context of procedural issues which are mirrored in other jurisdictions to varying degrees, and which exemplify the regulatory environment which can favour discharge over reuse.

Chapter 4 (published in the Australasian Journal of Environmental Management) provides an overview of barriers to wastewater reuse. The analysis of the drivers and barriers to wastewater reuse identified in Chapter 3 was extended into Chapter 4 which provided an overview of the broad discipline of the study of barriers to wastewater reuse as well as case studies comparing the wastewater reuse feasibility study from Chapter 3 with one from NSW where Hunter Water undertook a wastewater reuse feasibility study and planning for the Lower Hunter Water Plan (NSW). Chapter 4 goes on to discuss how differences in environmental regulation may impact feasibility. A discussion was also provided examining the broader impacts of distinct environmental regulation and agendas in the two case studies, notably load based licensing in NSW, different approaches to the study of wastewater reuse feasibility, varying governance approaches, and the manner in which regulators coordinate feasibility assessment.

Chapters 2, 3 and 4 each identified existing studies which point to important considerations for water investment including the inability to factor external impacts of wastewater disposal, public perception of recycled water, and willingness to pay for recycled water. In order to add new knowledge to this research area this thesis provided a review of the environmental regulations which control the human impacts of wastewater disposal, recreational water quality guidelines and management. Another observation within these chapters was that the regions of the case studies were outside of larger cities, and in many similar regions water scarcity may be a less significant driver for wastewater reuse than the need to prevent environmental discharge to meet obligations under environmental regulations.

Chapters 5, 6 and 7 of this thesis focused on the environmental regulation of the impacts of wastewater discharge. In addition to providing valuable reform options for more efficient regulation, this allowed for consideration of the assumption that environmental regulation is socially optimal. The thesis takes a new approach to this topic examining the role that recreational water quality plays in wastewater feasibility. Recreational water quality guidelines and practice are different in every Australian jurisdiction and therefore communication of recreational water risk from microbial pollution is not uniform.

Chapter 5 examined the state of recreational water quality monitoring for microbial risks in Australia with particular focus on communication and signage. Variation exists in Australian recreational water quality guidelines with respect to microbiological monitoring and communication of risk. Several states have more advanced systems for recreational water quality monitoring and communication which predict lower water quality and use multiple methods of communication. The NSW Beachwatch program has the most involved of these programs and is an ideal a model for a national approach. Western Australia has also put a greater than average effort into recreational water management and other states have benefited from their leadership.

Chapter 6 examined an Australian wastewater corporation (Melbourne Water) through a case study of the years leading up to the upgrade of a wastewater discharge. Media reports of public statements on the recreational water quality at an ocean wastewater outfall were discussed, along with media reports of illness. A review of scientific studies on the marine environment shows impacts to the marine ecological communities were recorded for several kilometers from the outfall itself. This case study demonstrates the issues with managing recreational areas where wastewater is discharged without inclusion of short term warnings in recreational water monitoring regimes. This case study also provided an opportunity to compare the history of public opposition and some of the public claims made of recreational water illness against actual scientific evidence, and to provide commentary on the efficiency of water quality guidelines in managing these factors.

The Chapter 6 case study demonstrated that compliance with environmental guidelines is not synonymous with a lack of risk or damage to the environment from wastewater disposal, and perhaps predictably, may not always reflect the wishes of all groups in society. This leads to a suggestion for future research to better understand societal preferences.

In Chapter 7 the case study of Launceston’s combined sewer overflow into the Tamar estuary provides a spectacular example of the liberty given to state health regulators by national recreational water quality guidelines. The significance of this system is that the collection of both stormwater and wastewater produces an influx of water during rain which overloads infrastructure, flowing untreated through inbuilt overflow points. CSOs in Launceston discharge wastewater directly to water flowing through the city which is used year round for secondary contact recreation with no warnings issued. Environmental and human health impacts are unknown and historically were likely clouded within a mediocre attitude and practice of watershed management. New catchment management practices by TEER and TasWater within their respective jurisdictions have improved this situation however issues remain.

Chapter 7 also highlighted an absence of protection for secondary contact recreation users in Tasmania. The absence of evidence of environmental conditions noted in Chapter 7 resulted from an absence of monitoring effort, raising the concern that by not applying flexible water quality guidelines less progressive states may effectively be using absence of evidence to justify inaction.

Also in Chapter 7, comparison was made with the regulation of similar infrastructure in the US highlighting an attempt to introduce legislation to mandate communication to the public of overflows, deemed as necessary even with a stronger system of environmental protection under the US constitution (by comparison to the weaknesses of a non-mandatory NWQMS demonstrated in Chapters 5 and 6).

9.3 Key findings

Table 8.1 describes the key findings in the thesis under three themes; 1) inadequacies in management disposal, described as an artificial legal separation between water in a terrestrial environment and once disposed to aquatic and marine environments; 2) water industry governance structures which may divert capital away from investment in water quality improvements; and 3) what has been described in this thesis as ‘coalescing concealment’ of transparent feasibility assessment. The contribution of various sections of this thesis to these themes is discussed below Table 8.1.

Table 8.1: Overview of key findings, details and reform options

Theme	Aspect	Specific details where applicable	Reform options
1) Artificial legal separation between water on land and once disposed to water	Environmental conditions for wastewater discharge are based around weak non-enforceable guidelines	Recreational water quality guidelines and practices in Tasmania allow risk where wastewater is disposed to be the responsibility of the uninformed citizen (Chapters 5, 6, 7) Environmental disposal guidelines estimate acceptable damage but actual impact may not be known (Chapters 6 & 7) Some evidence of incentives not to upgrade facilities in order to keep old licence conditions (Chapter 3) Danger that lack of effort in monitoring impacts justifies inaction due to lack of evidence of harm	Better integration of soft environmental goals into legally binding instruments Options include; • Update national guidelines to reflect modern technology • Independent cooperative research models • Funding linked to nationally consistent reporting
	Recreational water quality guidelines	Inter-jurisdictional variation; • National guidelines applied differently by every state • Variation in risk accepted • No secondary contact guidelines in some states • Variation in methods and pollution indicators used • Variation in when and how warning issued (Chapter 5)	• Reform state pollution control legislation NJ Baykeeper proposal to require notification (Chapter 7) Communication covered in national guidelines
	Pollution licences do not always	LBL licences compared to traditional licences (Chapter 4)	Hierarchy of management in national guidelines so that traditional

	provide incentives to reduce discharge	By comparison other obligations are required by law (for example the payment of profits from water corporations) (Chapter 3)	microbiological monitoring a last resort where reuse or safe disposal not an option Use of market based instruments such as tradeable wastewater disposal entitlements
	Lack of notification of human health risks caused by wastewater management	Community may not understand impacts of wastewater disposal Inconsistent communication of recreational water quality between regions (Chapter 5) No public notification required for Tamar CSO (Chapter 7) Even with developed monitoring program very hard to truly use monitoring to track health risks, better to manage wastewater to avoid health risks entirely (Chapter 6) In some jurisdictions inferior recreational water management coincides with underperforming infrastructure creating a situation of high risk and low warning/monitoring (Chapters 5 & 7)	
	Unenforceable guidelines show dependence on political and economic situation not environmental damage	Tasmania before and after reform (different outcomes, same guidelines) (Chapters 3 & 4) Environmental damage still 'compliant' under licences and guidelines for example Gunnamatta (Chapter 6, Chapter 7) Unenforceable guidelines are applied on a case by case basis when setting licences, creating a point of weakness in system (Chapter 7)	
2) Governance structures divert capital from water quality improvemen t to other areas	Governance structures which favour certain options, such as having to pay dividends when human health or environmental performance is not ideal	Tasmania reform to water corporation model clearly generated investment, however raises question as to water quality guidelines, unenforceability and appropriateness of removing money from water and sewerage (Chapter 3) No one takes responsibility for water quality in waters which are managed by multiple agencies lacking clear statutory responsibilities (Chapter 7)	Further research to measure efficiencies are gained from corporate structure and how this compares to dividends paid to government shareholders Use of market based instruments such as tradeable wastewater disposal entitlements

3) Coalescing concealment of transparent feasibility assessment	Less barriers to disposal than reuse	Regulations which do not provide economic incentives for achievement of goals desired by policy or society conflict water authorities as partly public servant part commercial entities (Chapter 3) Loose water quality management regime for disposal to water, compared to other more enforceable requirements, such as recycling on land or profit requirements (Chapters 3 & 4) General lack of prioritisation of recreational water activities in some jurisdictions (by comparison to more advanced jurisdictions)	Further research into economic benefits of recreational areas Recycling targets (water savings) or load reduction requirements reflected in binding legal mechanisms tied to reduced licence fees Research into how to factor comparative modernity of local environmental regulation into feasibility assessment Need for national cost benefit guidelines Use of market based instruments such as tradeable wastewater disposal entitlements
	Difficulties in determining/comparing true costs of reuse or disposal	Difficulties using regulatory compliance to indicate social or environmental costs or benefits, compounded by variation between jurisdictions Regulatory uncertainty within feasibility assessment process (Chapter 4) and some guidelines (Chapter 7) Absence of effort, weak guidelines and general difficulties in assessing recreational water risks, which may allow wastewater disposal impacts to be underestimated Self-fulfilling prophecy of polluting water and then it not being valued due to being polluted, NJ (USA) and Tamar (Tas) arguably demonstrate this. What would be the value without the disposal and if clean?	

9.3.1 Artificial legal separation between water on land and once disposed to water

Australian water quality guidelines accept a higher level of risk for people who swim or surf in areas impacted by wastewater than they do for people in areas where wastewater is applied to land. This is reflected in inconsistencies between recycled water and discharge water guidelines (Higgins et al. 2004). An uneasy balance is described where Australia-wide deficiencies in recreational water quality management are combined with out of date treatment technologies in some jurisdictions, meaning situations known to produce high levels of human health risk are combined with low levels of monitoring (Chapter 5 and Chapter 7). There is a need for future guidelines to be better informed of the risk people are prepared to accept of recreational water illness (Boehm et al. 2009). A financially important consideration for authorities is whether people who became ill and suffered loss after relying on safety assurances made without scientific evidence could pursue water corporations or authorities on claims of negligence, beaching their duty of care or other civil wrongdoing.

Flexible guidelines and uncertainty may be an as yet undescribed barrier to wastewater reuse; having unenforceable environmental guidelines with enforceable conditions being found in individual permits means polluters may seek to avoid upgrade in order to perpetuate older licence conditions, may create disincentives to private investors due to regulatory uncertainty, and when regulators are under-resourced, may be less likely to secure good environmental outcomes if total loads to a system were pre-determined prior to negotiation of the permit (described in Chapter 4). Water industry governance reform in Tasmania (Chapter 3) resulted in at least one reuse scheme, however broader issues remain with respect to structure, and comments cited in Chapter 3 which indicated there was a disincentive to upgrade because environmental permit conditions would be made stricter.

Chapter 7 is one example of problems caused by Australia's non-binding NWQMS. Although generally US federal water pollution laws have more legal force than Australian guidelines, EPA controls for CSOs are under US EPA policy not legislated in the Clean Water Act and there have been similar troubles for implementation, however investment and cooperation have resulted in improvements. In order to show how the issue of public risk from CSOs may be addressed a small case study is provided of an attempted State law reform to require the public to be notified when CSOs discharge untreated wastewater. Legislation which requires public warnings when untreated effluent is discharged, such as combined sewage and stormwater overflow during wet weather, could increase public safety. With respect to reuse, it is possible that if the public knew the number of times untreated sewage was disposed to the local waterway their willingness to pay for infrastructure may be altered. In which case lack of communication of impacts of disposal is a barrier to wastewater reuse not currently considered in Australia.

Variation in recreational water quality monitoring is another example of how activities in water are given less precedence in Australian environmental management. Chapter 5 describes how states have developed short term methods of warning swimmers when weekly samples are high including one and two sample trigger values, use of NHMRC 2008 as short term limits and the Enterotester which can produce site specific trigger values. Short term warnings are not present in NHMRC 2008 guidelines. Some Australian states have invested in modelling for predictive warnings of decreased water quality. Rapid microbiological monitoring technologies have been incorporated in US EPA guidelines since 2012. These may be appropriate for some jurisdictions in Australia, however research will need to be planned for in order to establish this for local settings.

The Chapter 6 case study demonstrates the application of water quality guidelines and provides an historical account of reports of illness attributed to an outfall, including 32 media reports which claimed human infections were caused by the outfall. The case study follows the responses of the water corporation to these claims. The utility frequently emphasised absence of risk and compliance with licence and guidelines. This demonstrates another aspect of communication to the beach closures discussed in Chapter 5, which is the communication of specific messages relating to wastewater discharge. This thesis contends that bathers could mistake compliance to indicate an absence of risk which independent science review and historical monitoring records shows was not the case. The case in Chapter 5 also highlights the need for procedures for reporting and warning of high results in water quality guidelines. While high single samples would be reported at Melbourne's bay beaches under the Beach Watch program (described in Chapter 5) they are not required to be reported at beaches impacted in this case study.

National guidelines need to incorporate the short term limits for recreational water quality already adopted by several states. Policy reforms are available to ensure a more consistent application of national recreational water quality guidelines. Firstly, binding between all Australian jurisdictions for consistent water quality regulation in Australia would be ideal, however national forums could be formed to allow agreement between various regulators, and provide clarity on which aspects of the guidelines are necessary in order to claim compliance and which provide more general guidance on implementation. Secondly, financial or other policy mechanisms to support uptake of national guidelines are recommended. For example, linking funding to reporting monitoring results to a national database in a consistent format is recommended.

9.3.2 Governance structures divert capital from water quality improvement to other areas

Governance structures which exist prior to and after a major reform of urban water governance have the potential to impact the timing and prioritization of investment. In particular, the reformed governance structure in Chapter 3 (post council management) found the regulator pushing a higher standard of environmental compliance for WWTPs. The need to balance spending priorities across all areas of Tasmanian water management to rectify historical underinvestment was a barrier to wastewater reuse. By contrast, the NSW case study in Chapter 4 showed a more consistent approach over time, with desired loads emitted described under the LBL process, and reuse being studied as part of the water planning process.

Tasmanian guidelines require wastewater reuse to be considered before disposal is approved. However differences in pre and post reform regulatory requirements arguably raise issues of regulatory certainty; discussed further in Chapter 4. The case study also highlights that TasWater and the State believed wastewater reuse schemes where wastewater is applied to land for uses which do not generate direct profit may have societal benefits and assist with regulatory compliance. This statement highlights a potential barrier to wastewater reuse in other jurisdictions, in that if there is an overemphasis on cost recovery from recycled water this may prevent wastewater reuse being used to avoid disposal; thereby providing an artificial structure ignoring a true assessment of which option has the best outcome, i.e., greatest net benefit rather than least cost.

Chapter 3 also discusses the appropriateness of water corporations being required to pay dividends to government owners while underperforming infrastructure causes environmental damage. Further, if wastewater management is not operated in a genuine, competitive market then application of pricing, while disposal options are considered part of the sanitation service, may hinder development of wastewater reuse. The chapter provides evidence of the incentives behind industry structure, and adds to existing literature (discussed in the Chapter) which questions whether a water bill is the best tool in which to collect assets to fund non-water related functions of local government. In doing so a direct quote from a State government elected official highlights that by creating a water industry governments were able to create an artificial divide between elected officials and water issues. Replacing ineffective and non-binding environmental guidelines with binding and effective environmental regulation may allow governments to keep the corporate structure, but prevent the need for profits outplaying social and environmental goals.

A philosophical question (raised in Chapter 3) for Australian water management is whether a whole of government approach supports the paying of dividends to government owners where environmental human health regulations are not being met. If these profits are paid regardless of the external impacts of water management this may remove the economic incentive for governments to reinvest that capital to maintain environments and enforce environmental legislation. If governments create no economic or political incentive to reinvest in water then this may hinder progress towards integrated water management. Water authorities do not make decisions on large scale recycling projects in isolation from other areas of government, which may support larger government-led planning for recycled water projects (as seen in Chapter 4) to better account for environmental, economic and social factors across a region.

Finally, governance structures impact responsibility and this may create artificial voids in responsibility, impacting spending on water quality improvements. For example, in Chapter 7 the discharge of untreated sewage is impacted by a hazy structure of responsibility between various agencies, as well as uncertainty created by non-binding and often aspirational guidelines.

9.3.3 Coalescing concealment of transparent feasibility assessment

9.3.3.1 Environmental regulations may distort decision making

The Productivity Commission (2011) warns that assuming wastewater recycling and reuse is in the communities' best interest without examining its costs and benefits produces inefficiencies, arguing the focus should instead be on removing impediments to recycling. If environmental standards reflect socially optimal conditions then by meeting these standards the environmental costs of a project will be internalized (Economic Regulation Authority 2009). This is an assumption made in the report of Marsden Jacob Associates (2013). Environmental and health regulations may distort urban water objectives by either creating a financial advantage to disposal that may skew an assessment of the costs and benefits of recycling, or by distorting public perceptions as to the impacts of either reuse or disposal.

Whether a local beach is open or closed on a regular basis may to inform an individual's decision making and willingness to pay for investment in wastewater upgrades or other water quality improvements. When discussing willingness to pay for recycled water, Marsden Jacob Associates (2013) contend that the value of direct environmental benefits of recycling, such as avoided discharges, produce minimal benefit compared to other factors, arguing that the power of environmental regulators in Australia mean that environmental harm is unlikely. This assumption is wrong for two reasons: 1) ineffective regulation can allow for environmental harm; and, 2) public perception may be varied by the information made available.

In relation to the first reason, the marine environmental impacts presented in Chapter 6 and Chapter 7 show the level of damage which is permitted under national and state guidelines and laws. In the case of Gunnamatta, a statement from the CEO of the water authority (Bayley, 2002, p. 61), as well as the upgrade process itself, indicate an admission that societal standards did not match what remained a legal and authorised practice. The outfall itself was finally upgraded to a higher discharge standard in 2012.

In relation to the second reason, the community's ability to understand the true impact of wastewater disposal is limited by the strength of environmental and recreational water quality monitoring as well as the ability of the public to access and understand this information. Decisions to enter the water have been shown to be influenced by many different factors including the absence of warning and signage (Lepesteur et al. 2008). However there may be issues with this. Chapter 5 described inter-jurisdictional variation of the accepted level of risk, when beaches were closed and what warning signage represented. In Chapter 6 the monitoring program demonstrated long term water quality but not high risk scenarios.

Investment decisions on water and wastewater infrastructure need to take into account the economic benefits from water quality improvements where improvements will be made in recreation waters. However, where water quality improvements are marginal (e.g. in waters which are already of a good quality) the financial benefits of further water quality improvements would be expected to be marginal (Ravenscroft & Church 2011). Unnecessary closures when waters are compliant can result in net economic costs, however, in one study these were found to be less significant than equivalent economic costs where beaches remained open when non-compliant, indicating that societal preferences for the level of risk remain significant policy considerations (Rabinovici et al. 2004). Another study found making European standards more stringent would likely have a positive economic benefit, however assessments of costs and benefits of recreational water quality will be influenced by the types of benefits and costs that are included in the assessment (Georgiou & Bateman 2005).

If recreational water illnesses are underreported (Boehm et al. 2009) they may therefore be equally underestimated in economic studies which rely on the accuracy of knowledge on recreational water illness and the extent to which exceedances of guidelines predict health outcomes in the real world. Some jurisdictions' levels of recreation have been shown to increase as indicators of water quality improved (Vesterinen et al. 2010), whereas in other areas, perceived health risks were found to be below actual health risks (Machado & Mourato 2002). If experiencing recreational water illness impacts perception (Lepesteur et al. 2008) it may be argued significant proportions of the population may not have knowledge on which to judge the policy question of accepted risk. Arguably, there is a risk when environmental impacts of wastewater disposal are not monitored, there will be less evidence of harm, and therefore a skewed decision making environment.

While beach users may have knowledge of the impacts of wastewater discharge, in the case of Chapter 6, it is conceivable that the majority of MW customers have not experienced the discharge by surfing or swimming at the site they are therefore reliant on statements of MW as to the environmental performance of the SEO. In Chapter 7 secondary contact recreational users are given no warning of the discharge of untreated effluent. For the countless smaller discharges across Australia where impacts are far less studied, the community's perception on the value of avoided costs is likely to be even less informed.

9.3.3.2 Procedural issues with feasibility assessment, regulatory uncertainty

This thesis has raised a key barrier to wastewater reuse; in many areas environmental regulation is the primary driver for wastewater reuse in the absence of water scarcity, however, inadequacies in environmental regulation hide the human and environmental impacts of wastewater management from wastewater reuse feasibility assessment. Inadequacies in environmental regulation produce regulatory uncertainty (Chapter 4) and issues of procedural transparency, and this may be an issue for wastewater reuse. Variation in environmental regulation may also impact the ability for externalities to be considered during the assessment of wastewater reuse feasibility. In Tasmania the same environmental regulations existed prior and post water industry reform but produced different outcomes in wastewater reuse feasibility assessment. This serves as a good demonstration of the problems which may be encountered under voluntary water quality guidelines, which is a theme which emerges throughout the thesis.

Another area of environmental management which may interact with wastewater reuse, which Chapter 4 addresses, is comparing environmental regulations using traditional licence fees to load based licensing. LBL charges more based on quantity of certain pollutants discharged, but allows polluters to reduce licence fees based on agreed or real reductions in discharge of those pollutants. The findings in Chapter 4 support those of the Institute for Sustainable Futures (2013), who found that load based fees were not a driver for reuse per se but would drive reduced discharge. However later chapters of this thesis build on this finding to argue that a solution to this may be in strengthening soft water quality regulations (in line with recycling and other risk). In some jurisdictions this may make disposal a simpler option than reuse. Chapter 4 focusses on barriers such as transparency and regulations which conceal the benefits or disadvantages of wastewater reuse or disposal. While Chapter 4 concludes that there is a need for a national cost-benefit assessment guideline for reuse, it is noted that one challenge which will need to be overcome to achieve this would be the alignment of inter-jurisdictional variability in the ability and desire for environmental regulators to factor externalities. The issue of regulatory uncertainty is returned to in Chapter 7, in this case looking at water quality guidelines.

Another option to make load based fees more effective could be to provide an economic incentive for recycling by factoring disposal of freshwater to marine environments into load based licensing for WWTPs. This would provide another mechanism to account for externalities. If this reform was considered, the result would be to expand the scope of the externalities considered to be covered by LBL schemes to drive water efficiency through pollution licences. Providing a financial signal for water efficiency would be better than the current situation where water authorities are expected to achieve water conservation in times of scarcity, while simultaneously increasing profits, when they collect revenue partly based on the volume used.

If decision makers truly desire to test the value of an improved recreational or environmental asset, a tradeable entitlement regime could be used. Market based instruments are included in Table 8.1 as a policy option because even a trial of these would help to economically connect the externalities of waste water disposal to the real costs of disposal, thus provide a link between land and sea law, provide an incentive to invest in upgrades rather than other water infrastructure, and provide heightened transparency for feasibility assessment because the ‘price’ (and externality costs) for disposal would be revealed.

9.3.4 Overview of recommendations

This thesis sought to identify areas not currently being considered in law reform. Measurement of public acceptance of recycled water and willingness to pay are important parts of current research on barriers to wastewater reuse. This thesis presented a range of evidence from case studies and reviews of legislation, policies and practice to argue that recreational water quality and other environmental regulation does not accurately portray environmental impacts. Inconsistent monitoring efforts or inconsistent communication of environmental externalities may result in a lack of data (or misleading data) on which both decision makers and the public can make these decisions. Key recommendations for reform include; 1) the development of guidelines for assessing costs and benefits of wastewater reuse, 2) investment in methods which strengthen non-binding and often aspirational guidelines, 3) provision of economic incentives for wastewater reuse where it is imposed on water corporations to meet societal goals which clash with requirements to operate in a commercial manner, 4) provision of funding for recreational water management including research for rapid methods and national collection of recreational water data reported in a consistent method, 5) better signage and reporting requirements for planned untreated wastewater discharges in Tasmania, 6) and inclusion of secondary contact recreation into Tasmanian guidelines.

9.4 Comments for ongoing policy development

9.4.1 Public perception of recycled water

This thesis discusses management practices which affect environmental impacts of wastewater discharge and therefore may impact public perception of the value of wastewater reuse. With respect to public perception of recycled water, the significance of public perception of recycled water for drinking as a barrier for wastewater reuse for drinking water is well documented (Hurlimann & Dolnicar 2010). However, without intending to dispute other authors on this topic, it is undeniable that historically societal preferences were not fatal to other large infrastructure projects for which State governments are proponents. For example, large scale reverse osmosis desalination in Australian cities was justified in a time of drought. By comparison wastewater recycling must now be justified economically on a case by case basis. Further, the decision to adopt large scale desalination in all Australian mainland cities and subsequent steadfast patronage of desalination by Australian State governments, water corporations and departments has ongoing consequences; firstly, desalination filled much of the gap between demand for water and supply in the capital cities, the cost of these projects increased water bills and therefore there is more focus on the financial aspects of recycling and other projects (Whiteoak et al. 2012).

Lessons have been learnt from the failed wastewater drinking water reuse scheme in Toowoomba Queensland. By comparison, in Perth the Water Corporation took the approach of commencing the process of investigating groundwater replenishment using recycled water in the Groundwater Replenishment Trial Project, an open process involving research and public consultation commencing in January 2007 with trial recharge not commencing until November 2010 (Water Corporation 2012). Furthermore, the successfully incepted potable water reuse scheme in Singapore used a longer period of media attention compared to a sudden peak in interest seen in Toowoomba (Ching 2010).

Although discourse on the public perception of recycled water has identified the ‘yuck factor’ as a key barrier to wastewater reuse, this thesis argues that another public perception barrier may be the perception of environmental and other externalities of the existing practice of wastewater disposal to water. If this public perception does not match reality then assessment of the societal and other benefits of wastewater reuse may be inaccurate. Chapters 2, 3 and 4 described some of the processes and issues encountered in determining whether to reuse or dispose wastewater. In particular, difficulties with using ‘willingness to pay’ as an indicator of reuse feasibility included large variation in extent externalities are communicated, lack of data of recreational water quality, and aspirational language used for environmental regulation, as described in Chapter 5. Further, in Chapters 3, 6 and 7 most of the risk or environmental impacts described were allowed under flexible environmental guidelines and management regimes. Caution is therefore required when economic studies make assumptions on environmental or social performance based on compliance with environmental legislation.

A further comment is that when estimating public perceptions and demand, small groups such as not-for-profits may have an unequal voice in the community due to ability to access media, however these groups may be unequally impacted by the externalities of wastewater disposal compared to other parts of society.

9.4.2 General comments for policy development

Existing ecological economic discourse on the externalities of wastewater disposal argues values may be undervalued in traditional cost benefit analysis, and these findings on deficiencies in recreational water management add another layer to that hypothesis. Arguably, the reforms to improve recreational water monitoring and communication (Chapter 6 and Chapter 7) may increase public awareness of negative impacts, or lack of negative impacts, which could impact willingness to pay for recycled water and also ensure the external costs of wastewater disposal are felt by the parties profiting from urban water and sewage not elsewhere.

It is the regulator or policy maker's role to decide the level to which water utilities should invest in dealing with market failures in the Australian water sector (including health and environmental externalities). The water utilities role is to meet these expectations at the lowest cost (Productivity Commission 2011). That said, most Australian jurisdictions have made little progress towards bringing environmental regulation forward into a modern market based approach. Alternatives to direct regulation include pricing through a load based licence (as in NSW) or allowing trading (Blackwell & Iacovino 2009, Frontier Economics 2011). Providing a financial signal not to pollute would appear to align more closely to the Productivity Commission's statement as to the role of the regulator and the utility. Under such an approach increasing or decreasing the loads of specific pollutants has direct financial consequences decided by environmental regulators prior to and away from the competing priorities which can be present when investment decisions are made.

These financial signals contrast determining the costs or benefits of wastewater disposal by considering them as part of a decision on willingness to pay by customers who are not privy to the full information and therefore cannot make an informed choice or valuation. Where water scarcity is not a driver for wastewater reuse but governments seek higher targets for water recycling it may be necessary to subsidise this use to achieve the policy, or to make water efficiency an external impact considered within the load based licensing scheme as discussed above.

The current focus on high valued recycled water schemes has allowed either inadequately treated water to degrade environments, and in other cases where supply far exceeds demand very high quality recycled water is disposed (such as the Eastern Treatment Plant in Melbourne, the South East Queensland Western Corridor Recycled Water Project and others as highlighted by Whiteoak et al. (2012)). In situations of low demand (or perhaps more accurately, low demand for expensive water) there appears to be a philosophical barrier to wastewater reuse; where supplying the water at a loss is a better result for the public than disposing it at either a poor quality which degrades the environment or a very high quality which arguably wastes energy and money. The current predicament of recycled wastewater reflects the artificial construct that is the Australian water industry; where profits or losses are determined by examining the financial impacts within segmented organisations which in reality seek the same purpose as the whole of government, that is, to provide services to the public in the most efficient manner with no harm.

To use Victoria as an example, desalination was pushed through from a government level above the planning of the water managers and planners. By comparison (with the exception of several large scale projects) recycling projects are carried out by water authorities or local governments. As a result it is not allowed to operate at a whole of government level; the polluter pays principle and issues with polluted recreation areas are not harnessed adequately so as to provide economic or social incentives to promote recycling. In addition, assessing recycling at the level of some smaller water management regions means assessment of feasibility for individual projects may ignore potential efficiencies across larger regions.

9.5 Limitations and future research

As a review of legislation and management this study has identified weaknesses in regulation and institutional processes and areas for reform. It provides in depth examination on one aspect of the potential environmental impacts of wastewater management, recreational water, as well as identifying areas for reform in the specific jurisdictions of the case studies.

Despite this, the thesis does not explore economic regulation of the water and sewerage industry. For example, a question for study within the economic discipline would be how to factor variation in environmental standards into decision making on wastewater reuse schemes? The economic impacts of health impacts of wastewater disposal, increased recycling and other options are unknown, although there is a developing body of work in this area referred to throughout this thesis. This thesis raises numerous questions which would be suitable for future research; for example; 1) what would the economic and social benefits be if recreational water quality and management was to improve so that there were fewer errors; and 2) how does this compare to the costs of increased effort and research to provide this lower level of risk?

With respect to the weaknesses in recreational water management identified in this thesis, an underlying question remains; if more information was available describing the impact of wastewater on environmental and social values would this alter community perception or alter decision making frameworks in favour of reuse and protection of waters? Some research in this area is discussed in this thesis however, the question is still undecided as to how and when information on water quality alters behaviour. Such a question would need to be the study of further research. The intention of the thesis was to find evidence in support or otherwise of the hypothesis, and in doing so the thesis has identified areas for reform and future study. Further, if application of water quality guidelines in a location is below the national standard, this does not necessarily mean there will be negative impacts which outweigh the costs of additional infrastructure.

This thesis described recreational water quality guidelines and extrapolated this to describe the extent of understanding the impacts of marine pollution on humans; conditions for monitoring may be included in individual discharge licences and these would impact this outcome. As each WWTP holds an individual licence this was beyond the scope of this thesis, but may be appropriate for further study.

Although streamlining legislation may appear ideal, study is required to understand the outcomes on decision making of informal processes such as when decisions are made on individual wastewater discharge permits or reuse schemes. In particular research could examine whether the current case-by-case approach produces the most efficient and accurate outcomes, whether the burden of assessing every application creates costs for society which compare to the benefits that are gained over having a single limit applied to all areas and contained in legislation.

Actual knowledge on what the human health implications are for a given body of recreational water in Australia will often be unknown, and therefore a limitation of this thesis is the assumption that accepting a lower standard of risk than that recommended in NHMRC 2008 guidelines will have negative impacts. This is unknown, although it could be argued that the lack of study in this area further highlights inadequacies already discussed in this thesis. It is still necessary to state that by examining legislation, guidelines and practice this thesis only identifies areas that are deficient, and suggests that the effect of these be studied as areas of future research. On the other hand, where the reforms in this chapter apply to consistency of standards, this is one purpose of federal water policy, and therefore the results and proposed reforms remain valuable regardless of not being able to test the precise impact.

Chapter 6 does not consider the impact of media interpretation on the statements made, nor does it claim to verify the truth of the reported assertions of recreational water illness. It was intended to provide this information as part of the collection of information to inform and tell the story of the case study, rather than to conduct social science methods on a very small sample size of newspaper reports. In addition future research could apply media analysis and other methodologies to study whether the amount of news coverage is of significance and through the analysis of all statements made by the water authority to allow analysis of how the media modifies information provided by the water authority. Actual community perception of risk could be the subject of further study, in accordance with suggestions of Lepesteur et al. (2006). A key theme of such research could be the intention and impact of water industry and regulators statements on environmental risk, as well as the accuracy and scientific basis for these. Reports of recreational illness in newspapers are only evidence that a report was made only and not the truth of the assertion. There are often financial or practical difficulties for decision makers wishing to collect actual evidence of disease burden through an epidemiological study.

9.6 Conclusion

Even where disposal is discouraged in guidelines and recycling is encouraged in policy, differences in protection of water environments through environmental regulation of wastewater disposal and recreational water standards mean that there are simply fewer barriers to disposal than there are for reuse. Therefore, strengthening environmental regulation of wastewater disposal, and making polluters pay through some form of pollution entitlement, would be expected to create incentives to reuse wastewater.

In order to comprehend the financial value of clean water, decision makers need to view themselves as investors in the future. An investor does not assess the value of an undervalued asset based on what it currently represents but instead uses knowledge and imagination to see its potential. As such, investors determine the amount of money to invest based on the economic and social return the asset would provide once the improvement has been made. In this way of thinking an investment of capital into a degraded building on the edge of a city is viewed for the building's potential to be apartments or offices or parkland; the investor takes the profit of the difference between their investment and the value of the improved asset and society benefits through an improved city. With respect to wastewater, citizens are denied valuable community amenity and recreational assets because financial assessments of the costs to society of disposing wastewater are made based on the current degraded conditions. In this way, the degraded nature of the environment prevents use, and therefore there are fewer incentives to repair it, even though we are financially and technically capable of doing so. Money which would have been available is then diverted off through dividends to pay for other priorities of government owners. The weak environmental regulations have undervalued the future potential of the environmental asset and the investment made in not polluting it was not matched with its potential value as a clean waterway. Rather than assessing willingness to pay based on current environmental performance, this requires an understanding the current and potential uses of an area, such as the money that improved recreation would bring to the area in order to compare the likely increase in value with the amount of money required for the infrastructure upgrade. Even were the market value of potential uses for disposal environments falls below the cost of an upgrade, non-market values from conservation of marine ecosystems or cultural heritage (e.g. surfing and surf lifesaving etc.) may tip the scales in favour of an upgrade.

9.7 References

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APPENDIX 1

1.1 Newspaper articles collected for Chapter 6 search

Table A.1: Details of articles collected for public debate section of Chapter 6 including whether health, environment or specific incidents were mentioned and Melbourne Water statement as recorded by newspaper source.

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
AAP Australian National News Wire (2006a)	Vic: Libs would close Gunnamatta Beach sewage outfall	Infections from surfing mentioned	No	N/a	No	No
AAP Australian National News Wire (2006b)	Vic: Greens want more water savings	No	No	N/a	Greens policy mentioning closure of outfalls.	No
AAP Australian National News Wire (2006c)	Vic: Vic govt announces $300 million water recycle plan	No	No	N/a	No	No
ABC Premium News (2005a)	Libs promise end to sewage outfall	No	No	N/a	Liberal statement describing moves to recycle wastewater.	No
ABC Premium	Protesters rally against	No	No	N/A	No	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
News (2005b)	Gunnamatta Beach sewage outfall					
ABC Premium News (2006)	Melbourne Water rejects water wasting reports	No	No	N/a	Water wastage	No
Baker (2001a)	$170m push for sewerage clean-up	Yes	No	‘Mr Bayley said the plan would also include a massive reduction in ammonia levels in effluent and a review of the need to extend the ocean outfall pipeline near Gunnamatta Beach. He said the upgrading would make the effluent being discharged from the plant among the highest quality in the world and allow the recycled water to be used for a greater range of agricultural purposes.’ ‘[“]We've got to be honest about what we can achieve," Mr Bayley said. "Ocean discharge is a fact of life around the world, but that doesn't mean we don't work hard to minimise the effect on the environment. But I don't see the technology, the means or the market to completely recycle everything at this stage[“]’	Yes	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
Baker (2001b)	Surfie 'brothers' challenge Thwaites	Surfrider president; ‘surfers were constantly reporting ear, eye and throat infections after being in the water’	No	N/a	No	Surfrider President; ‘He said condoms, tampons, cotton buds and balls of animal fat were often found on the beach or in the water.’
Baker (2002)	Gunnamatta sewage pipe to stay	N/a – discusses panel findings	No	N/a	No	No
Black (2002)	Recycling is smarter	No	No	N/a	Waste of water resource	No
Catherine (2007)	Vic: Garden hose revival as tap turns on recycled water	No	No	N/a	Recycled water use protects Gunnamatta beach	No
Clifton-Evans (2012)	Surfers' bad break GUNNAMATTA CALLS TO CLEAN UP OUTFALL PIPE	Yes	Septicaemia requiring hospitalisation	‘[“]’No untreated sewage has spilt from the plant into the ocean," she said, ``and we release treated effluent into the ocean . . . under a strict EPA Victoria licence[“]’	No	No
Cutcliffe (2007)	Just another Gunnamatta	N/a – editorial on desalination	N/a	N/a	N/a	No
Dowling & Weekes (2006)	We'll close sick beach outfall, vow Liberals	Yes	‘…Jeff Lim, 48, of St Andrews Beach, contracted viral meningitis and a	‘Melbourne Water, which treats Melbourne's sewage, also tests for bacteria on the shoreline near the outfall at Boags Rocks, which is	No	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
			kidney infection within a week of surfing at Gunnamatta. He was bedridden for eight weeks and took a year to recover.' Brian Archibald, 47, of Mount Eliza, said he was in hospital for five weeks with viral meningitis and brachial neuritis and forced to take six months off work. Melissa Mackie, 30, of Mount Martha, said she contracted severe tonsillitis within 30 minutes of swimming at Gunnamatta. "I was bedridden for a week with vomiting, headaches and dizziness," she said. Luke Beerling, 24, of Tootgarook, spent five days in intensive care, after being diagnosed with viral pneumonia.'	between St Andrews Beach and Gunnamatta Beach. It points to research that shows the outfall has no health risks for humans.'		

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
Duncan (2006)	Vic: Libs to close sewage outfalls	Yes, 'Gunnamatta has long been the subject of protests by environmentalists and surfers, who claim infections from surfing in the tainted water are common.'	Refers to a different newspaper article which references EPA data; 'enterococci at 45 times the EPA's acceptable level. Eighteen of 85 tests at the site since 2000 delivered bacteria readings'	N/a	Yes	Quoting David Davis – 'You could see the plume, the diatom, spreading for kilometres out to sea and down along the coast. At Rye back beach, three or four kilometres from the Gunnamatta outfall, you could see a bathtub ring of brown along the high tide mark.'
Fyfe (2002a)	Peninsula sewer plan under fire	Surfing Victoria threatens to boycott beach due to children contracting sore throats and ear infections	No	EPA arguing for outfall extension. Melbourne Water arguing for improved effluent quality instead.	Yes	EPA Chairman says shoreline outfall no longer acceptable. Resident concerns extending outfall will extend where effluent ends up. Clean Ocean Foundation concerned 'the EPA's decision is an "out of sight, out of mind" solution that will simply relocate the pollution and affect marine life'.
Fyfe (2002b)	Surfers may catch more than just waves as sewage levels soar		Director of Surfing Victoria; "Parents have complained that their children have picked up sore	'Melbourne Water's research and technology manager, Peter Scott, said yesterday the water was of good	Yes	'With an onshore wind, the tournament director remembers seeing "huge plumes of brown" floating into the

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
			throats and ear infections there. ‘Surfing Victoria's head Max Wells said yesterday: "We've been running our events at Gunnamatta for years but at this stage we are really feeling there is a chance we are endangering the lives of our competitors." Mr Wells was concerned that Surfing Victoria could be legally responsible if a child became seriously ill.[”]’	quality. It fell within EPA guidelines and there was "a very low risk”. The only way to get to the bottom of surfers' complaints would be a major health study, and this would be too difficult and too costly, he said.’		contest area. "You could see the stuff and you could smell it. It was unbelievable," Mr Clarke said. Surfing Victoria, the state's main surfing body, yesterday threatened to boycott the Mornington Peninsula and scrap surfing competitions there because of the Gunnamatta sewage outfall, which releases 370 million litres of treated effluent into the ocean each day.’
Fyfe (2004)	Surfers ban Water Minister	No	No	N/a	Clean Ocean Foundation describing Water Minister as a polluter.	No
Fyfe (2010)	Confusion on what's the matter at Gunnamatta	Yes	Impetigo infection.	‘… the monitoring results from the Gunnamatta outfall… consistently showed the water quality was "good" to "very good". The statement said a 2001 Monash University report had found no increased risk of illness for surfers or swimmers at Gunnamatta.’	No	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
Fyfe and Morton (2005)	Pollution endangers surfers No warning about contamination	Yes - Clean Ocean Foundation comment on Melbourne Water test results	No	'But Melbourne Water said the results could be aberrant, as only a thin strip of water appeared to be contaminated, with cleaner water either side. "We've never had results as dramatic as this before. We went back to the laboratory and questioned it, but they could not throw any light on it," said Peter Scott, a Melbourne Water general manager. The water authority said the tests were part of its voluntary program to build up a history of water quality data near the outfall. The tests were not a warning system and the time to get results back - a few days - made it too late to warn surfers. Only 2 per cent of 3600 tests conducted over five years were above the safe limit, Mr Scott said. The EPA, which normally issues safety reports about beaches, said warning people about Gunnamatta was an issue for the Health Department. The authority would not take action against Melbourne Water unless results were consistently over the limit across a year.'	Yes	Ammonia levels and impact of intertidal reef, whether short or long outfall.

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
				The EPA and Melbourne Water insist that surfing and swimming near the pipe - which carries half of Melbourne's treated effluent - is safe. But surfers regularly complain of ear, gastric and eye infections.'		
Geelong Advertiser (2006)	Libs plan to shut beach sewer pipe	Refers to claims from surfers of infections.	No	N/a	No	No
Guerrera (2004)	MP urges Bracks to tackle Gunnamatta waste worry	Clean Ocean Foundation President mentions surfer illness	No	'Melbourne Water yesterday defended its discharge practices, saying it met all EPA licence requirements.'	Yes	Wasted resource (Water)
Hagan (2006)	Foul slick blamed on ocean outfall	Yes	No	'A spokesman for Melbourne Water, Ben Pratt, said there was no indication the water conditions were connected with its sewage outfall. Preliminary results of testing by the Environment Protection Authority on Wednesday found the discolouration and odour was due to a high presence of microscopic algae. EPA senior science manager, Tony Robinson, said it was similar to an incident last month. "At this stage there is no evidence to suggest the material is harmful or poses a threat to marine life," Mr Robinson said.["]'	Yes	'Smelly brown water' at Gunnamatta and nearby beaches.

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
Herald Sun (2006)	Libs to clean up	'Environmentalists and surfers have long claimed that infections from the tainted water are common.'	No	N/a	No	No
Hudson (2002a)	Residents in a stink	No	No	N/a	'It is enormously harmful to the environment'	No
Hudson (2002b)	Sewage stink	Yes	No	N/a	No	No
Hudson (2005)	Stop dumping sewage on beaches: MP	Yes - Greg Hunt MP – 'Mr Hunt said sewage dumping was damaging kelp, aquatic life and coastal quality, and that surfers had reported viral and other infections from Gunnamatta'	No		Yes	Greg Hunt MP – 'Mr Hunt said sewage dumping was damaging kelp, aquatic life and coastal quality….'

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
Hunt (2006)	A whiff of a scandal	Yes	No	N/a	Yes	Opinion piece refers to destruction of kelp beds and fish breeding habitat and permanent grey slick on water. Water recycling and efficiency issues.
Hunt (2007)	Decade of water down the drain	No	No	N/a	Editorial – Water wastage discussed	No
Kellett (2010)	Gunnamatta sickness link	Yes	22 respondents to survey report marine related illness	'[“]This monitoring shows that water quality consistently achieves good to very good under National Health and Medical Research Council classifications.[“]'	No	No
Ker (2008)	Recycled water safe for Yarra	No	No	N/a	Mentions water continuing to flow to Gunnamatta.	No
Ker (2009)	Gunnamatta outfall plan dumped	Yes	No	'…planned upgrades to the filtration process at the Eastern Treatment Plant meant the two-kilometre extension pipe was no longer required. Technological advances meant the water could now be treated to such a high standard it would have minimal impact on the marine environment close to shore.'	Yes	No
Koutsoukis (2004)	Gunnamatta priority in push to end ocean outfalls	Yes	No		Yes	Wasted resource (Water).

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
Koutsoukis (2006)	Water recycling under spotlight	No	No	N/a	Greg Hunt MP discussing water conservation issues and sewage 'being dumped'.	No
Miller (2000)	Peninsula sewer pipe spews waste on to beach	Yes	No	'Melbourne Water managing director Brian Bayley said it was virtually impossible for litter to be discharged from the Carrum plant. He said the pipeline was now under continual surveillance. Melbourne Water was considering how to make access points along it tamper-proof.'	Yes	'…a tide of used sanitary items, cotton buds and other litter near the Boag's Rock outfall…' Refers to ammonia levels.
Minchin and Miletic (2006)	Mixed welcome for sewage plans	No	No	N/a	No	No
Mornington Peninsula Leader (2009)	Better water in pipeline	No	No	'Melbourne Water asset planning general manager Paul Pretto said a year of high-tech trials had revealed a new way to treat waste water to "virtually eliminate impacts of treated effluent discharged into Bass Strait, near Gunnamatta". Mr Pretto said the upgrade would see Melbourne Water's Eastern Treatment Plant become "one of the most sophisticated sewage treatment facilities in the world by the end of 2012["].'	Yes – refers to eliminating "impacts"	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
MX (2006)	Water upgrade more than drop in the ocean	No	No	N/a	No - Mentions plan to cut outflows.	No
N.A. (2001)	Protesters take to water	Yes	No	N/a	Yes	No
Opitz (2012)	Sewage overhaul long overdue	'….ear and throat infections and gastrointestin al illnesses.'	No	'Plant manager Charmaine Quick said the upgrade would not only improve water quality to a tertiary level but also reduce the amount being discharged at Gunnamatta and increase the potential for using recycled water.' Goes on to discuss recycling.	No	'Water at the Gunnamatta outfall is tinged with brown'
Royall (2002)	Time for a clean break	Yes – year 11 student opinion on surfing at Gunnamatta	No	N/a	No	No
Strong (2004)	$1bn plan to send treated water to Gippsland	No	No	N/a	Concerns for recycling using ETP effluent; 'Another concern is that treated sewage contains pesticides and pharmaceutical s, including antibiotics and estrogen from the contraceptive pill.'	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
The Sunday Age (2006)	Something to be frothed up about down at Gunnamatta	Ear infections, respiratory and dermal problems, viral meningitis	No	'…an upgrade of the Eastern treatment plant at Carrum, which processes 42 per cent of Melbourne's sewage, is under review.'	Yes	No
Titelius (2000)	Surfers shun filthy beach	"Surfers and swimmers regularly suffer from sore throats, stinging eyes and nasal problems."	No	'EPA chairman Dr Brian Robinson said greater efforts were needed to investigate re-use of effluent.' '["]It should have been actioned 10 years ago," he said. ``We also want to see immediate action on quality of effluent by reducing ammonia levels. It's time to move the agenda along . . . we can't avoid this any longer.["]'  'Melbourne Water's science and technology manager Peter Scott said a CSIRO study in 1998 showed that the water quality was ``good and met requirements".' 'But the study found that ammonia and fresh water had harmed native seagrass beds which had been taken over by hardier species.' 'Mr Scott said although tests had shown water quality met requirements, he acknowledged that beach users had concerns.	Yes	Surfrider foundation says water discoloured and smells of ammonia.

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
				He said Melbourne Water was regularly monitoring the water and listening to surfers' concerns.'		
Titelius (2001)	Surfers cry foul over outfalls	Yes – 'This concentrated release of semi-treated effluent is also seriously affecting the health of the people who use the ocean.'	No	'Melbourne Water managing director Brian Bayley said although CSIRO studies had deemed the water safe for swimming, the authority did not recommend swimming near the outfall. He said Melbourne Water was planning to modify its treatment plant at Carrum to reduce ammonia levels.'	Yes – 'environmental damage'	'Kilometres of coastline have been completely denuded of much of the original marine vegetation' – Clean Ocean Foundation spokesman
Topsfield (2008a)	Libs urge action on ocean spill	Greg Hunt MP: 'Surfers still go there because it is such a great break, but they report numerous examples of ear infections which you simply don't get from other beaches.'	No	No	'…the equivalent of 55,000 Olympic-sized swimming pools full of off-colour, treated sewage is flushed into Bass Strait every year.'	No
Topsfield (2008b)	Opposition shows its colours	No	No	N/a	'55,000 Olympic-sized swimming	No

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
					pools of off-colour, treated sewage is flushed into Bass Strait every year'	
Wilmoth (2006a)	A beach where the waves are truly sick	'gastric, ear, respiratory, skin and eye infections and, in six cases, viral meningitis'	Ear infections, another surfer contracted viral meningitis, another complained of an infected cut	'Melbourne Water spokesman Ben Pratt said that during the recent algal bloom, enterococci and E.coli levels were within EPA licence limits and those considered safe for recreation. Acting EPA chairman Bruce Dawson wrote to The Mornington Peninsula Leader last week saying EPA data showed enterococci levels during the bloom were within safe levels. "EPA has reviewed Melbourne Water's compliance with its licence during this time and has found that the outfall at Gunnamatta has operated within its required licence limits," he said. "There is no evidence to suggest raw sewage has been discharged from the outfall[“]'	Yes	Clean Ocean Foundation claims diatom bloom result of outfall as a result of high levels of ammonia and bacteria. EPA Victoria denies this.
Wilmoth (2006b)	Gunnamatta 'very good' despite sewage	Yes	No	Promotion of NHMRC rating. Statement; '[n]o significant microbiological health risk to swimmers or surfers" at St Andrew and Gunnamatta beaches.'	No	No
Wilmoth (2006c)	State silent over outfall	Yes	'Surfer Mitch Nibbs sustained a cut to his face at Gunnamatta in 2004 that needed six	'…the nature of micro-organisms meant that samples varied day to day and that assessment over time more accurately reflected the beach condition, and that was why "we have	Yes	

Author	Title	Health mentioned?	Specific health incident?	Melbourne Water statement re health	Environment mentioned?	Specific environmental impact?
			months of antibiotics to heal. “There were scabby, pussy sores all over my face and neck,” Mr Nibbs said.’	adopted this approach", of not yet releasing the data.’		
Wilmoth (2006d)	Thwaites refuses early release of Gunnamatta Beach tests.	Yes	No	‘The general manager of research and technology at Melbourne Water, Peter Scott, said the nature of micro-organisms meant that samples varied day to day and that assessment over time more accurately reflected the beach condition, and that was why "we have adopted this approach", of not yet releasing the data.’ ‘A spokesman for Mr Thwaites said Gunnamatta was one of the most monitored beaches in Australia. The unpublished information was part of a long-term study, he said, and that it had "absolutely nothing to do" with the election.[“]’	Yes	‘Mark Akester, an environmental scientist with the non-aligned Clean Ocean Foundation, said he believed the turbulence on the shoreline reduced the number of bacteria but "beyond the wave action there's a problem - and that's what they're failing to reveal.’
Wroe (2006)	States face shame over water waste Victoria 'squandering' 350bn litres	Yes	No	N/a	Yes – Opinion of Greg Hunt MP on water that is not recycled.	No

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APPENDIX 2

2.1 Further information on interview methodology

The use of interviews was authorized under Human Research Ethics Committee (Tasmania) minimal risk ethics approval (H0011863) (the Ethics Approval). The original methodology proposed the use of a survey instrument which could also be used as a structured interview, conducted either online or by telephone interview, and a generic introductory email which would be used to approach to a large number of water related organisations in order to secure a higher number of participants.

During the course of the research closer cooperation with several water authorities was secured through a Water Research Australia 2012 PhD Scholarship. Following consultation with industry contacts issues were identified with this method. In practice there is only a small number of individuals who are able to provide constructive comments on this specific topic. This is restricted to those with actual involvement with the facilities or the policy or guideline. Generally one relevant person was identified in each organization. Relevant staff to interview were often interstate or overseas which can cause further difficulties in ensuring the information gained is relevant. The information likely to be obtained from a broad survey of general staff was therefore of less utility than specific information obtained through interviews with key personnel.

As a result, in 2013 an amendment was sought to this ethics approval. This included an amendment to allow; 1) subjects who are interviewed over the phone or skype to provide consent without having to return the signed information sheet, 2) to allow organization names to be listed in publications with permission of individuals, and 3) to reflect that a generic recruitment process and survey was no longer be necessary or relevant, as participants were recruited through other methods and interview would generally follow the open ended questions which were previously approved under the ethics approval.

Interviews were conducted with NJ Baykeeper, the Office of the Tasmanian Economic Regulator, Ben Lomond Water, NRM North, the Tasmanian Health Service and West Tamar Council. Notes of the interviews were typed and stored with any recordings in the office of the Chief Investigator of the research. Interviews were de-identified for personal details of the individuals concerned. In addition a series of site visits was conducted outside of this interview process in order to gather information to guide the development of the thesis as a whole. This included Hunter Water (NSW), Water Corporation (Western Australia), Western Corridor Recycled Water Scheme (Queensland), Southern California Coastal Water Research Project (USA), Orange County Sanitation District, and Beaconsfield Waste Water Recycling Facility (Tasmania).

The small number (6) of formal interviews were used to request crucial information, such as the frequency of water quality testing, when warnings may be issued, and which documents and guidelines to refer to. The open ended interview was necessary because of the different professional backgrounds of each participant. For example, the questions that may be asked of a wastewater engineer would be entirely irrelevant if posed to a health regulator. The thesis does not rely on direct statements from interviews as evidence for conclusions and the interviews were used largely to point to existing information or to obtain documents which are cited in the thesis. This information is factual in nature and therefore no further analysis, statistical or otherwise, was deemed necessary. The approach of avoiding citing individual opinions was justified to protect interviewees, because where interviews were conducted with one specific individual within an organization their identity may be identifiable through their opinion.

Transcripts of the interviews were typed and stored along with voice recordings in the office of the Chief Investigator of the research. All data was stored on password protected university computers during the investigation. Interviews were de-identified for personal details of the individuals concerned and are stored in a locked cabinet in the office of the Chief Investigator, to be destroyed 5 years after the date of PhD approval by destroying DVDs containing electronic data and shredding any documents.

2.2 General guiding questions

The following are examples taken from the Ethics Approval (H0011863) which demonstrate the nature of the questions used to lead the final interview process.

1. Do you think that most operating licences or permits in this jurisdiction require that wastewater discharges meet State or National water quality policies for marine or estuarine water quality?

2. Are there factors external to your organisation which prevent or impede compliance with licence, permit or guideline requirements for receiving water quality?

3. If a facility was frequently breaching a discharge licence or permit would this encourage changes to be made to improve the quality of treated wastewater?

4. If the discharge licence or permit breach increased in severity would this also increase the speed at which these changes came into effect?

5. If recycled water customers frequently complained about the quality of recycled water would this encourage changes to be made to improve the quality of treated wastewater?

6. Which policies prohibit the use of recycled or purified recycled water as a substitute for drinking water?

7. Do you have an example of an Australian or international facility or jurisdiction that shows current best practice wastewater management?

8. Are there any other barriers to the efficient management of wastewater?

2.3 Email and information sheet

2.3.1 Email:

Dear ________,

Thank you for agreeing to participate in this study. Please find the attached information sheet which contains important information relating to the ethics approval for this research. We will consider your receipt of this email and participation in the interview as evidence of your consent to these conditions.

Please note that you are consenting to us using your organisation's name in future publications but not your name, position and personal details. If you wish to participate the interview but do not consent to us using your organisation's name you may notify us of this in writing by responding to this email.

Thank you for taking the time to assist in this valuable research.

2.3.2 Information sheet:

PARTICIPANT INFORMATION SHEET

SOCIAL SCIENCE/ HUMANITITES

RESEARCH

What are the cross jurisdictional barriers to the efficient and effective recycling and reuse of wastewater, currently not being considered in Australian law reform?

Invitation

You are invited to participate in a study examining the appropriateness of Australian water quality standards. The study is being conducted by Simon Perraton of the National Centre for Marine Conservation and Resource Sustainability as part of a PhD under supervision of Dr Boyd Blackwell, Dr Troy Gaston and Professor Gary Meyers.

1. ‘What is the purpose of this study?’

The purpose of this study is to investigate whether it is possible to identify and remove any policy or regulatory barriers to wastewater recycling in Australia. This stage of the study aims to identify any policy or regulatory barriers that may exist in the area of wastewater management in Australia.

2. ‘Why have I been invited to participate in this study?’

We are seeking participants who are involved in wastewater or environmental management roles. Eligible participants should be involved in the water management industry and your insight into decision making and management of wastewater resources in accordance with National, State and local guidelines and standards.

3. ‘What does this study involve?’

Interviews are expected to take approximately 20 minutes to complete. It is important that you understand that your involvement is this study is voluntary. While we would be pleased to have you participate, we respect your right to decline. Although a complete set of answers is required to ensure the rigor of the analysis, if you decide to discontinue participation at any time, you may do so without providing an explanation. All information will be treated in a confidential manner, and your name and organisation will not be identified in any publication arising out of the research. All of the research will be kept in a locked cabinet in the office at the University of Tasmania. Data will be destroyed five years after the study is completed by destroying DVDs containing electronic data and shredding hard copies of participant responses.

4. Are there any possible benefits from participation in this study?

If we are able to take the findings of this small study as well as the output from a broader legal review of wastewater management the result may be valuable information for others and it may lead to increased efficiency in Australian water management laws.

5. Are there any possible risks from participation in this study?

You should be aware that we are unable to advise you whether information you disclose would be considered above and beyond that which you are able to disclose under the conditions of your employment. As participation in this study is entirely voluntary you may choose to not answer any or all questions, or to provide an answer at a later date.

7. Will my personal details be published?

All data emanating from this project will be coded as a means of protecting your anonymity and confidentiality. Your name will be removed however we will retain your organisation or department details. If you do not agree to us retaining your organisation details please reply to this email and inform us of this that you wish to participate but do not consent to this aspect. Given that the information you are likely to be sharing is not of a controversial or harmful nature, the risk to you is minimal. Additionally, you may request the opportunity to review material prior to publication and request the removal of any information that you feel may identify you.

6. What if I have questions about this research?

If you would like to discuss any aspect of this study please feel free to contact either Simon Perraton on (03) 6324-3762 or Chief Investigator Dr Troy Gaston on (02) 4349 4569. You are welcome to contact us at that time to discuss any issue relating to the research study.

7. Has the study been approved by the university?

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226-7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote H11863.

8. How do I inform of my willingness to participate?

By participating in this interview you are implying consent to the conditions within this information sheet. Thank you for taking the time to consider this study.